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November 1934

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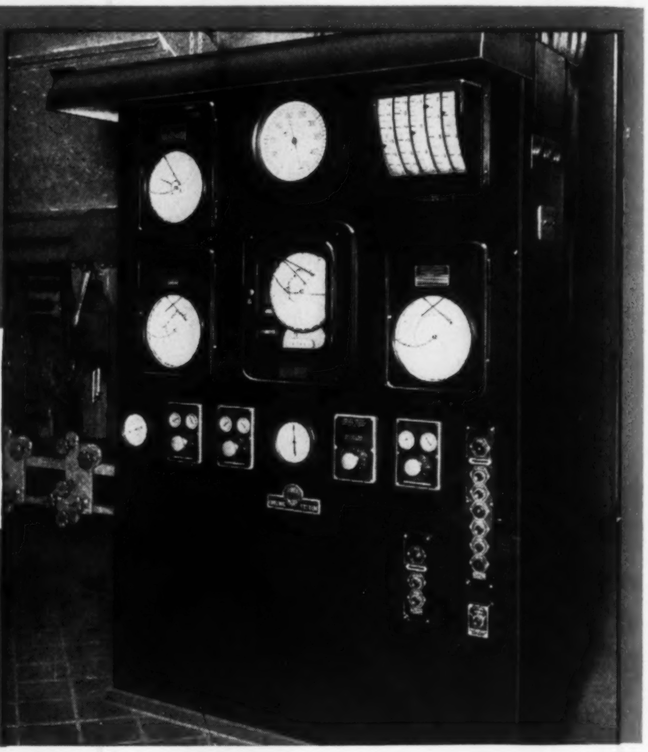

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MECHANICAL ENGINEERING

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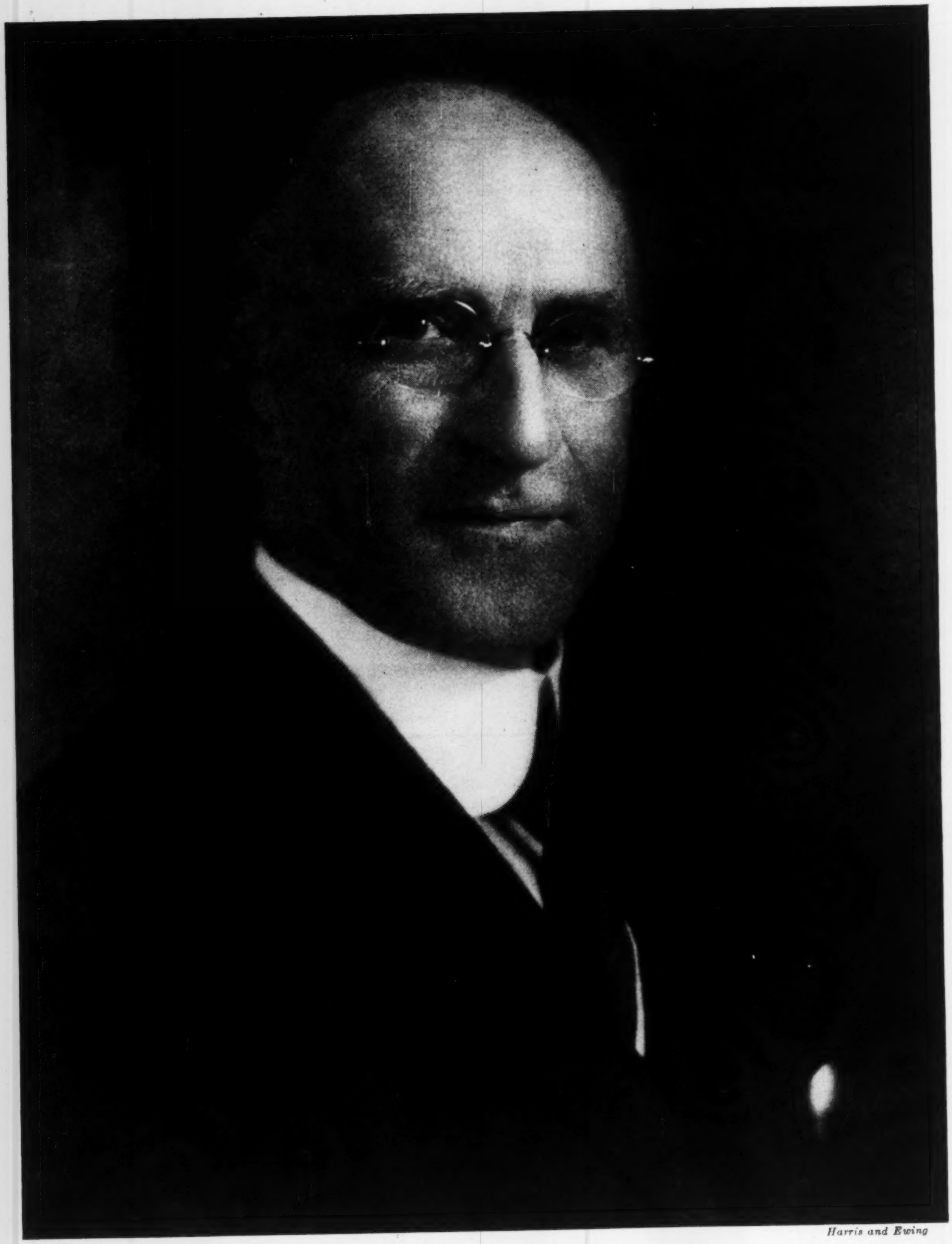


Harris and Ewing

Calvin Winsor Rice, 1868-1934

CALVIN WINSOR RICE

1868-1934

STRICKEN at his desk in the midst of his daily work, and in the building which his vision, enthusiasm, and energy had greatly helped to bring into being as a headquarters for the professional engineering societies of the United States, Calvin Winsor Rice, honorary member and for twenty-eight years secretary of The American Society of Mechanical Engineers died as a result of cerebral hemorrhage on October 2, 1934, a few hours after his removal to a nearby hospital.

Although he had won distinction as an electrical engineer in the practise of that profession prior to 1906, he will be most widely remembered for his services to The American Society of Mechanical Engineers as its secretary and for his vision and leadership in that office, which not only developed that society greatly in numbers and in virility, but the entire engineering profession as well. For the spirit of cooperation with which he worked brought together the numerous individually organized groups of engineers in joint activities for common purposes. Of this spirit, the Engineering Societies Building in New York is a substantial and glorious monument, the physical embodiment of that vision and idealism that were Dr. Rice's most abundant gifts.

HIS QUALITIES IN PROFESSIONAL-SOCIETY ORGANIZATION

At the time Dr. Rice was made an honorary member of The American Society of Mechanical Engineers, in December, 1931, Dr. Karl T. Compton, president, Massachusetts Institute of Technology, delivered an address on his work in professional-society organization and paid a splendid tribute to this phase of his career. In the address, which was published in the January, 1932, issue of MECHANICAL ENGINEERING, Dr. Compton listed six essential qualifications for leadership in engineering-society organization which Dr. Rice possessed to a marked degree: (1) The ability and desire to cooperate with others; (2) the ability and judgment to recognize a good project when it was suggested; (3) initiative and drive to carry a project through to completion; (4) daring to undertake an audacious project, once convinced of its merit; (5) originality of thought; and (6) ability to organize, to delegate authority, and to spur others on to take active part in the affairs of the Society. Dr. Compton listed in addition four principles that were basic to Dr. Rice's philosophy of society organization and operation: (1) Unselfish cooperation with related societies; (2) planning actively for the future, so that development might not be haphazard, and so that opportunities for development in the desired direction might be quickly and firmly grasped when they presented themselves; (3) giving the most effective service to the members of the profession; and (4) leading the profession in rendering the most valuable possible service to society. The great number of engineers who knew Dr. Rice were conscious of these elements of his character and these principles of his philosophy.

HIS INTERNATIONAL REPUTATION

One characteristic feature of his career, resulting from these personal qualities, brought distinction to him, to the society he served, to his country, and to the profession of engineering. This was his relationship with engineers in this and other countries. In Great Britain, in Europe, in Mexico and South America, and in the Orient, Dr. Rice was well known in engineering circles. He traveled frequently in the discharge of his duties, and his office in New York was a focal point upon which converged the paths of engineers, eminent and obscure, who came to the United States. He was never too busy to give letters of introduction to engineers from abroad, or to engineers of this country planning to travel in Europe. Members of the Society frequently found that letters from Dr. Rice were more effective in gaining for them admission to some foreign plant or factory than similar letters from business men and engineers in the country they were visiting. The bread of hospitality and service he continually cast upon the waters wherever he happened to be returned in abundant measure to him by way of courtesies shown all over the world to those for whom he bespoke consideration. In students coming to this country Dr. Rice had great interest, going out of his way to have arranged for them itineraries of plant visits and advising them on educational and professional programs. These active international relationships brought Dr. Rice into high esteem, both here and abroad, and year by year added to the list of those beholden to him for help, advice, and innumerable lesser courtesies.

SIGNIFICANT EVENTS IN HIS CAREER

Dr. Rice was born at Winchester, Massachusetts, on November 4, 1868, the son of Edward Hyde and Lucy J. (Staples) Rice. After attending public schools in Boston, New Haven, and Winchester, he spent four years as a student in the Massachusetts Institute of Technology, from which he was graduated in 1890 with the degree of bachelor of science in electrical engineering. He then held, successively, positions as assistant engineer in the power and mining department of the Thomson-Houston Company in Lynn; as engineer in the General Electric Company in Schenectady; district engineer for that company in Cincinnati; engineer with the Silver Lake Mines in Colorado; consulting engineer for the Anaconda Copper Mining Company in Anaconda, Montana; electrical engineer of the Kings County Electric Light and Power Company, and later with the New

York Edison Company and the Consolidated Subway Company; vice-president of the Nernst Lamp Company; consulting engineer with the General Electric Company in New York. It was from this rich and varied experience in electrical, hydraulic, and steam engineering, combined with managerial and administrative work, that Dr. Rice was called to the secretaryship of the A.S.M.E. in 1906.

THE ENGINEERING SOCIETIES BUILDING IN NEW YORK

Dr. Rice became a member of the A.I.E.E. in 1897, and was active in its affairs. In 1900 he joined the A.S.M.E. The story of his part in the bringing together of the engineering societies in a common headquarters building in New York and of the manner in which the funds were secured was told by Dr. Compton in his tribute to Dr. Rice previously referred to. Dr. Compton said:

> In 1902, as chairman of the Building Committee of the A.I.E.E., he called a dinner meeting of the committee, together with the president of the A.I.E.E., Prof. Charles F. Scott, and several others, to discuss plans for a modest building for the Institute, primarily to house the Latimer Clark Library, which had been presented to the Institute by Dr. S. S. Wheeler on the condition that a fireproof building be secured to house it. The Committee had, at that time, definite prospects of only about $250,000. When President Scott suggested that consideration be given to the possibility of a building for housing the four National Engineering Societies, with a common library and a common auditorium and individual rooms for the headquarters of each society, doubts were expressed as to whether the four societies could be brought into such a cooperative project.
>
> Strenuous efforts, which were at the last minute successful, were made to get Mr. Andrew Carnegie as a guest at the next annual dinner of the Institute. At this dinner President Scott outlined his ambitious plan and pointed out its fine features—including the library.
>
> The next day Mr. Carnegie asked Dr. Rice to come to his residence at five o'clock, and Dr. Rice, with characteristic thoughtfulness for others, as well as admiration for the lofty character of his president. brought with him Professor Scott. There Mr. Carnegie asked them further about the work of the Institute, about the finances of the engineering societies, about the relation of the proposed building to the Engineers' Club (of which he was a member). Dr. Rice cleverly inferred that an obstacle in Mr. Carnegie's mind was the securing of the land, for the latter was not in the habit of buying the land on which the libraries which he donated were built. Dr. Rice then optimistically remarked that the Engineering Societies would be able to provide the land, whereupon Mr. Carnegie gave a cheerful smile and said, "If you can provide the land, I will put up the building." Dr. Rice was made chairman of the building fund.
>
> Then the money had to be raised to buy the land; complications and difficulties in perfecting the organization and developing the plans had to be overcome. In the words of Professor Scott, "Mr. Rice's devotion to the idea of a building for the Institute and his skill in directing the early conference with Mr. Carnegie and his enthusiastic and faithful assistance in subsequent service to the Institute in carrying out the project were fundamental factors in the creation of the Engineering Societies Building and the separate building for the Engineers' Club."

THE KELVIN MEMORIAL

Among other incidents that illustrate Dr. Rice's faculty of initiating projects that bore fruitful results may be mentioned the Kelvin Memorial Window, in Westminster Abbey, told by Dr. Compton in the A.S.M.E. address, and the establishment of the Officers' Reserve of the United States Army, a brief account of which was contained in a letter by the late Gen. William Barclay Parsons published in *The Military Engineer* for March-April, 1931. Dr. Compton's account of the Kelvin Memorial Window is as follows:

> In 1910 Dr. Rice had a most unique experience, an account of which has never before been published. That year the A.S.M.E. made a return visit to the Institution of Mechanical Engineers at their Birmingham meeting. Remembering that in a modest way the A.S.M.E. had contributed to the memorial window in Westminster Abbey to Sir Benjamin Baker, honorary member, A.S.M.E., Dr. Rice wrote to the Dean asking if it would be permissible for the members of the A.S.M.E. when passing through London on a certain Sunday, to visit the Abbey and view the window. Not only was permission granted but a special service was arranged, with a sermon on engineering by the Bishop of Lewes, and on this occasion the "Hallelujah Chorus" was rendered by the full surpliced choir. The event was further made memorable by having the A.S.M.E. audience arranged in a semi-circle about the memorial window, the movable pulpit having been placed beside it.
>
> Dr. Rice noticed that every window in the entire Abbey, save one, was a memorial window. The unappropriated window was apparently an original plain-glass window and was very dull by comparison. The next day Dr. Rice called on the Dean to express gratitude, and in conversation commented on the unoccupied window. The Dean immediately responded that the Abbey would appreciate a gift of a memorial window. Dr. Rice thereupon sensed the situation and offered a window, knowing it would be an easy matter to collect from the entire English-speaking world an amount sufficient to install a window to an engineer.
>
> Dr. Rice proposed a window to his friend Lord Kelvin as one mutually desired by the Abbey and by engineers. Consistently he arranged that this memorial be provided through the cooperation of the engineering bodies of Great Britain and the United States. Having obtained instant approval of influential persons in England, he used the same method in the United States, and, when the undertaking was assured, placed the whole proposition in the hands of the Institution of Civil Engineers, the oldest and most important engineering organization in the world, for announcement of the popular subscription.
>
> The result was so successful that not only was the window provided but the Kelvin Medal was founded. This is probably the only joint undertaking of this nature by the English-speaking world.

THE OFFICER'S RESERVE

In a letter to General Parsons, Dr. Rice said that he had commenced agitation for an Officers' Reserve in 1902, when he went to Washington to take the matter up with Gen. Nelson A. Miles, then Chief of Staff. He was unsuccessful, but he kept repeating his suggestion up to 1914. From General Parson's letter in *The Military Engineer* the following passages are quoted:

> By the end of the year 1914, there were some engineers who perceived that the world was in for a long period of war and that no matter what position of neutrality the United States might for a while assume, it would probably inevitably be drawn into the conflict. Mr. Calvin W. Rice, secretary of The American Society of Mechanical Engineers, had this view and became firmly impressed with the belief that the engineers should be organized for action.
>
> After conferring with Major-General Leonard Wood, then commanding the Department of the East, Mr. Rice organized a luncheon in February, 1915, at which were present, besides Mr. Rice, Dr. Henry S. Drinker, President of Lehigh University, Mr. Elmer E. Corthell, Mr. Ralph Mershon, Mr. Bradley Stoughton, and a few others, with General Wood as the guest of honor. On being asked for advice, General Wood pointed out that for many years there had been established, as part of the Army, a Medical Officers' Reserve Corps, who were duly commissioned in the Army and who were subject to call to duty in case of war and in times of peace with their consent. This Reserve had been found to be most beneficial, as officers were drawn from it at times of emergency and then could return to private life when the stress was passed. He showed that engineers, like doctors, were always mobilized for the practise of their profession and that an Engineer Officers' Reserve, parallel to the Medical Officers' Reserve, might be established.

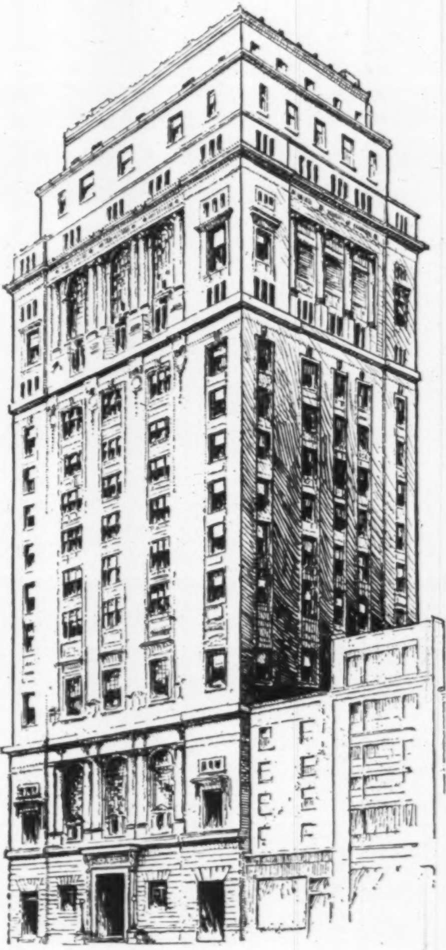
> This suggestion of General Wood's was promptly taken up, and committees were appointed on behalf of the engineering societies. . . . These committees were immediately organized and began to work, but it was found more expedient to form a central executive and operating committee of the chairmen of the separate committees. . . . The Chairman of the Joint Committee [Arthur S. Dwight] proceeded to Washington to lay the proposed plan before the War Department. He went with some misgivings as to how such a radical suggestion, emanating from civilians, would be received. His misgivings, however, were quickly dispelled. The Secretary of War, Mr. Lindley M. Garrison, received him cordially and sympathetically and by him was presented to Major-General Hugh L. Scott, then Chief of Staff. General Scott, after hearing what the chairman had to say, introduced him to Major-General Tasker H. Bliss, Assistant Chief of Staff. General Bliss listened attentively and with much interest, and at the conclusion of a long interview sent for Major W. D. Connor, now Major-General Connor, an officer of the Corps of Engineers attached to the General Staff. General Bliss instructed Major Connor to confer with Mr. Parsons and to prepare a joint report for submission. When this was done, General Bliss studied it carefully and said, "You have proved your case for engineers, but why limit it to them? It has always been my wish that there should be established a general reserve as part of the Army of the United States." He then returned the report, asking them to make a plan for such a general reserve. . . .
>
> The outcome was that the joint committee reported to the five societies under date of June 23, 1916, that "a bill, which recently passed the Congress, has been signed by the President and will become effective July 1, 1916. This bill, known as the Army Reorganization Act of 1916, contains provisions for the organization of an Officers' Reserve, including the engineers."
>
> Thus a movement initiated by Mr. Rice, put into concrete form by General Wood, and carried into execution by the Committee of the Engineering Societies, was authorized by law.

Dr. Rice, in his modest manner, was very proud of the part he played in the establishment of the Officers' Reserve.

HIS EDUCATIONAL AFFILIATIONS

Inspired by the work and character of Dr. Oskar von Miller, distinguished director of the Deutsches Museum, for whom he had a warm affection and high regard, Dr. Rice became interested in the educational possibilities of exhibits of the industrial arts. This brought him into active working contact with a group of men of enthusiasm and vision who established what is now the New York Museum of Science and Industry. As honorary secretary and a member of the board of this institution he gave freely of his energy and advice up to the time of his death.

To his Alma Mater he gave his services as member of the Corporation of the Massachusetts Institute of Technology and chairman of the visiting committee of the department of mechanical engineering of that institution. His broad acquaintanceship among engineers brought him into close contact with other institutions, for his advice was frequently sought when a professorship, a deanship, or a presidency was to be filled.



ENGINEERING SOCIETIES BUILDING, NEW YORK, N. Y.

HONORS AND PROFESSIONAL CONTACTS

In addition to membership in the A.S.M.E. and the A.I.E.E., of which he was a former vice-president, Dr. Rice was a member of many other engineering and professional societies. He was an honorary member of the association of members in Argentina of the National Engineering Societies, of the Koninklijk Instituut van Ingenieurs, of Holland; of the Club de Engenharia, of Rio de Janeiro; of the American Society of Safety Engineers; of the Masaryk Academy, Czechoslovakia; and of the Deutsches Museum, Munich, Germany. He was corresponding member of the Instituto de Engenieros de Chile and of the Technisches Museum, of Vienna. In 1915 he served as a member of the Jury of Award of the Panama-Pacific Exposition. In 1922 he received a gold medal at the Centennial Exposition of Brazil. On him were bestowed the Order of the White Lion of Czechoslovakia, and the Golden Ring of Honor of Bavaria. He was a fellow of the American Association for the Advancement of Science, and a member of the Institution of Electrical Engineers, of London and of the New York Electrical Society. His well-known interest in research won for him membership in the division of engineering and industrial research of the National Research Council, and the position of National Counselor of the Purdue Research Foundation.

As a delegate of The American Society of Mechanical Engineers to the Seventy-Fifth Anniversary of the Verein deutscher Ingenieure, held in Cologne, in 1931, he was the recipient of a medal of honor "in appreciation of his services to technical-scientific achievement, particularly in promoting the mutual international interests of the engineers of the entire world." Among other honors in Germany he received the honorary degree of Doctor of Engineering (Dr.-Ing. E.h.), from the Technische Hochschule, of Darmstadt, Germany, in 1926.

Dr. Rice married Ellen M. Weibezahn, of Winchester, Mass., August 6, 1904, who, with his children, Edward Winslow and Marjorie Charlotte, survives him.

1934 A.S.M.E. ANNUAL MEETING

ON PAGES 695 to 700 of this issue will be found the program of the Annual Meeting, December 3 to 7, of The American Society of Mechanical Engineers. Such of these papers as were received in time have been published in the October issue of the A.S.M.E. Transactions, 12 in number, and about ten more will be published in the November issue. The present issue of Mechanical Engineering contains one paper to be presented at the meeting. Other papers will appear in later issues of the Transactions and Mechanical Engineering. Because of the policy of the Committee on Publications of preprinting papers in the Transactions, opportunity is afforded for study of these papers prior to presentation. It is expected that this will stimulate valuable discussion. In later issues of the Transactions the discussion, and the authors' rebuttals, will be published.

Society affairs will receive first consideration at the meeting. On Sunday noon delegates from the local sections' conferences will meet with members of Council, following which they will engage in a series of conferences with representatives of the Finance Committee, the Engineers' Council for Professional Development, the Committee on Publications, the Executive Committee, and, after a buffet supper, the Committee on Policies and Budget. The purpose of these conferences is to provide an interchange of ideas and information on Society matters. On Monday morning the conferences will be resumed with the Council, and in the afternoon the annual business meeting of the Society will be held.

For the technical sessions the program should be consulted. A registration fee of $1 will be charged non-members (but not members of the A.S.M.E. or of any of the societies with whom joint sessions have been arranged) for attendance at technical sessions.

In addition to the usual Towne and Thurston lectures, the Calvin W. Rice Lecture will be delivered on Wednesday afternoon at 4 o'clock. The occasion will be a tribute to Calvin W. Rice, for twenty-eight years secretary of the A.S.M.E., and the lecture will deal with Dr. Rice's contributions to international friendliness.

At the annual dinner, which will be held at the Hotel Astor, as usual, the A.S.M.E. Medal, the Holley Medal, the Worcester Reed Warner Medal, and the Melville Medal will be presented to the medalists nominated by the Committee on Awards. The Junior Award will be presented at the Presidents' Reception, Tuesday evening, and the Chas. T. Main and two Student Awards will be presented at the Student Branch luncheon, Wednesday. Two honorary memberships will be annnounced on Presidents' night.

While practically the entire program will be held in the Engineering Societies Building, a portion of it will be conducted Thursday afternoon and evening at Stevens Institute of Technology, at Hoboken, N. J. In the afternoon the session on economics will be devoted to a discussion of problems of recovery of the durable-goods industries. In the evening the Gantt Medal will be presented to Wallace Clark and Horace Cheney and the Towne Lecture on the relation of engineering and economics will be delivered by Dexter S. Kimball, Dean, College of Engineering, Cornell University, past-president, A.S.M.E.

As usual a number of other engineering societies are joining with the A.S.M.E. as co-sponsors of certain sessions and papers. They are the American Society of Heating and Ventilating Engineers, the American Society of Refrigerating Engineers, the Institute of Aeronautic Sciences, the Taylor Society, and the Society of Industrial Engineers.

Opportunity will be provided, as in the past, for visitors to New York to participate in excursions to power plants, industrial establishments, and other points in the vicinity of interest to engineers. These will be announced later. A program of events for the entertainment of the ladies is also being arranged. Provisions are being made for special luncheons of committees and for the usual large number of meetings of technical and other committees.

It is expected that there will be a large attendance of mechanical engineers at this meeting. One of the bright spots of the past few years when engineers in general have felt the full force of the depression has been the surprisingly large and enthusiastic numbers of men that have come to Annual Meetings of The American Society of Mechanical Engineers and the extent and excellence of the technical program and discussion.

This is encouraging evidence that engineering progress continues in spite of unfavorable economic conditions.

REDUCED RAILROAD RATES

MEMBERS of The American Society of Mechanical Engineers planning to attend the 1934 Annual Meeting in New York, December 3 to 7, should secure certificates which will entitle them to return tickets at the rate of one-third the regular one-way fare. Certificates must be validated at the headquarters of the Society during the meeting. The return ticket must be purchased by December 11. Tickets so purchased will then be good for return passage to reach the original starting point within thirty days from the date of sale of the going ticket as shown on the certificate. It will, of course, be necessary to return by the going route. The one-third fare return rate will be available to members of The American Society of Mechanical Engineers, The American Society of Heating and Ventilating Engineers, The American Society of Refrigerating Engineers, The Institute of Aeronautic Sciences, the Taylor Society, and the Society of Industrial Engineers.

Attention is called to the fact that unless one hundred certificates are validated at headquarters, it will be impossible for any one to secure the reduced rate. Therefore, any one whose one-way fare to New York City is 75 cents or more should obtain a railroad certificate. From Eastern and Mid-West sections of the country tickets and certificates will be available from November 30 through December 6, while from the Pacific Coast certificates will probably be issued a few days prior to December 1.

HYDRAULIC VALVES *and* GATES *for* BOULDER DAM

Part IV—The Design and Construction of the Bulkhead Gates

By P. A. Kinzie[1]

DURING the earlier phases of the main construction of Boulder dam, it was essential that a large area of the river bed in that region embracing the zone within which the power-plant footings, draft tubes, and the base of the dam would rest should be exposed, that this zone should be drained, and that the sand, gravel, and boulder mass filling the bottom of the gorge beneath the river bed should be excavated down to sound rock some 120 ft below.

To accomplish this purpose four diversion tunnels, 50 ft in diameter inside their finished concrete linings and 56 ft in diamerer before concreting, were blasted through the solid rock of the canyon walls to carry the river around the dam-site excavation zone. (See plan view, Fig. 1.) These tunnels, disposed in pairs on each side of the river, have been and are now serving this purpose while the huge pit to receive the base of the dam and the power plant was being dug down to sound rock and the concrete was being placed therein.

Since the time when the bed rock in the bottom of the ancient river gorge was exposed and the necessary trimming of the irregular surfaces was completed, concrete has been poured almost continuously in the dam and the power plant at an unprecedented rate under the efficient and vigorous management of F. T. Crowe, of the Six Companies, Inc., so that today some 2,500,000 cu yd are already in place and the top of the concrete in the dam now stands at, approximately, elevation 1000.

The sequence of construction of Boulder dam was so arranged that when the concrete had been poured in the dam to a height where such procedure would be safe against overtopping during a flash flood, one of the two 50-ft diversion tunnels on each side of the river could then be plugged during the low-water period prior to the time when the construction program requires the closing of the two remaining tunnels.

In order that the ultimate expenditure of some $65,000,000 of Government funds required for the dam, outlet works, and power plant may begin to earn dividends at the earliest possible date, it will be necessary to stop the flow of water around the dam through these last two tunnels as soon as construction has advanced sufficiently to make this step safe, in order that the tremendous storage space in the river valley behind the dam may be filled to higher and higher levels progressively, as the concrete in the dam is poured to higher elevations, and so raise the water surface until it finally reaches the level of the intake towers, flows through the lower cylinder gates into the 30-ft headers into the turbines, and thus makes the initial generation of power possible. It is for the closing of these last two 50-ft diversion tunnels that the equipment about to be described is provided.

At the upstream or inlet portals of these two tunnels, heavily reinforced-concrete structures have been constructed with massive portal braced beams 56 ft above the tunnel inverts spanning the space above and in front of the tunnel entrances to carry the erection platforms on which the two structural-steel gate leaves, 55 ft wide by 51 ft high by 12 ft 7 in. thick, were built. Arrangements were such that the flow of the diverted river through the tunnels was unimpaired during the assembling and riveting of these gate leaves.

One of these gate structures with the completed gate leaf supported on the erection platform may be seen in the upstream elevation and in sections *A-A* and *B-B* of Fig. 2. In this same figure, section *C-C* is a horizontal section on a larger scale through the right-hand end of the gate leaf, roller trains, stationary and movable wedges, and the roller tracks and stationary wedges, with their supporting reinforcing beams embedded in the concrete of the portal structure.

Before proceeding further with the description it is appropriate that the peculiar conditions which these installations were required to meet should be given, in order that all which follows may be more easily understood.

STUDY OF CONDITIONS AND POSSIBLE SOLUTIONS

Boulder dam will have a storage capacity of 30,500,000 acre-ft. This is equivalent to the total average flow of the river over a period of nearly two years and is sufficient to cover the state of Connecticut with water 10 ft deep, creating the largest artificial lake in the world. The river usually reaches its maximum flow during May and June of each year. During the remainder of each year the flow is but nominal, and at times is not sufficient to supply the domestic and irrigation demands of the lands below. In order that the initial storage space in the lower portions of the reservoir may be filled progressively as the dam is built higher and higher, and yet avoid the hazard of overtopping the partially completed dam by premature closure of the last two diversion tunnels, it is essential that these be closed either before or after the peak of the early summer flood has past, and at a time when there still remains enough assured run-off from the melting snows on the Western slopes of the Rocky Mountains in the upper basin states to fill this lower storage space in the reservoir, so that the inflowing waters from the upper drainage areas will produce the same approximate rate of rise of the water surface behind the dam as it is built progressively higher.

Attacking the problem on this basis, it was found that it might be necessary to close the last two diversion tunnels with 70,000 cfs of flow passing through the two, and it was also found that with gates of the size required to close these 50-ft tunnels it would not be practicable to raise them again after closure, if they remained closed longer than four days.

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[1] Engineer, U. S. Bureau of Reclamation, Denver, Colo.

Presented on "Reclamation Bureau Night," at the Semi-Annual Meeting, Denver, Colo., June 25 to 28, 1934, of The American Society of Mechanical Engineers. Published by permission of the United States Bureau of Reclamation. Parts I, II, and III appeared in the July, September, and October issues, respectively.

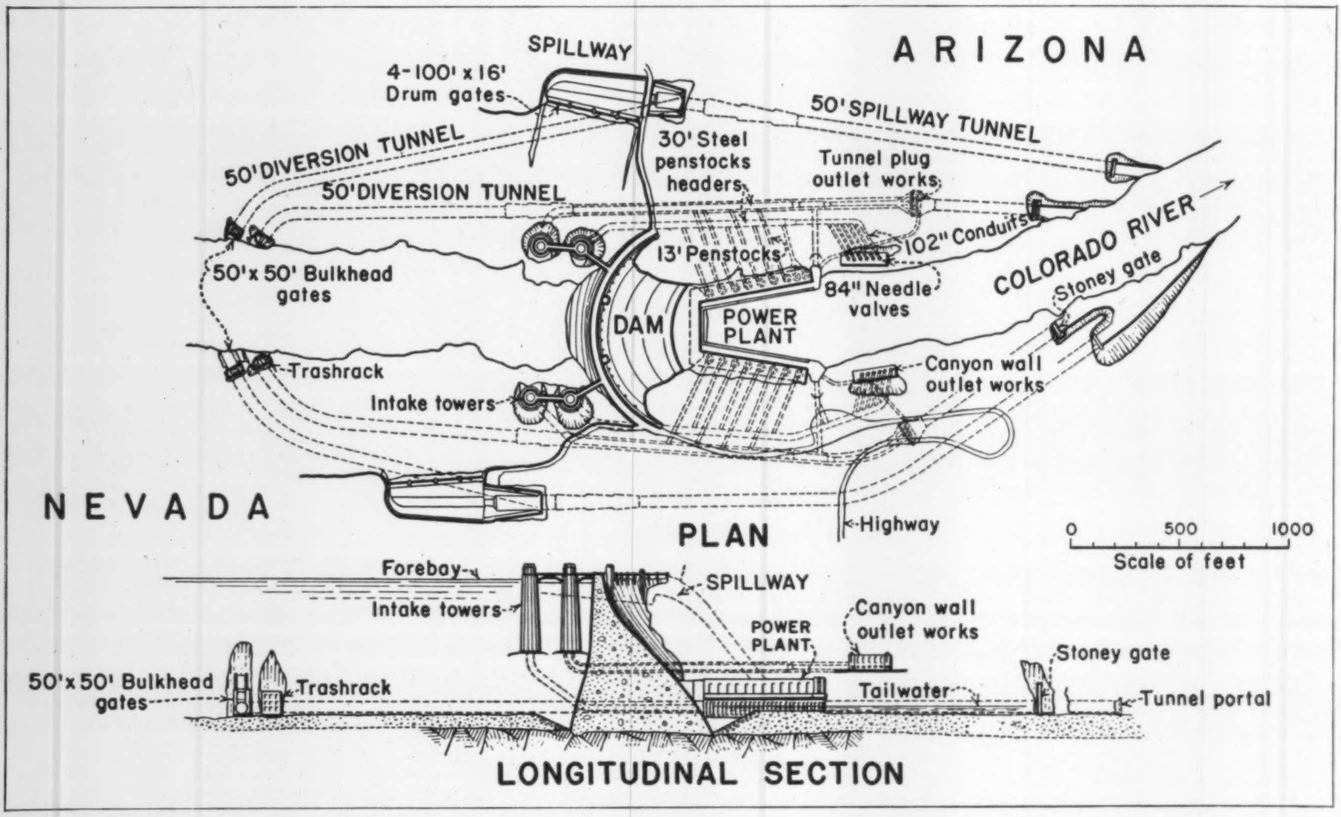
SPILLWAY
4-100' x 16' Drum gates
ARIZONA
50' SPILLWAY TUNNEL
50' DIVERSION TUNNEL
50' DIVERSION TUNNEL
30' Steel penstocks headers
Tunnel plug outlet works
102" Conduits
COLORADO RIVER
13' Penstocks
50'x 50' Bulkhead gates
84" Needle valves
Stoney gate
DAM
POWER PLANT
Trashrack
Canyon wall outlet works
Intake towers
NEVADA
PLAN
Highway
0 500 1000
Scale of feet
Forebay
SPILLWAY
Intake towers
Canyon wall outlet works
POWER PLANT
Stoney gate
50'x 50' Bulkhead gates
Trashrack
Tailwater
Tunnel portal
LONGITUDINAL SECTION

FIG. 1 GENERAL LAYOUT OF BOULDER DAM AND ASSOCIATED WORKS SHOWING LOCATION OF THE BULKHEAD GATES

Computing the time required to install the concrete plugs in these tunnels after the gates had been closed, it was found that the water level in the reservoir would probably reach elevation 940 and the gates would accordingly have to be designed to stand 300-ft head on their bottom sills.

There now remained the development of the equipment best adapted to meet these governing conditions and many forms of design, construction, and operation were developed to insure that the best possible solution of this problem would be secured.

Specifications 519 covering the general construction of Boulder dam included a tentative design for the closure of these tunnels. This consisted of a heavily reinforced monolithic concrete slab 63 ft 6 in. wide by 53 ft 6 in. high by 21 ft thick, weighing 5350 tons and supported on each side of the tunnel portal by three steel cylinders 6 ft 6 in. in diameter by 59 ft 6 in. high. These cylinders were to be filled with concrete and were to act as columns and rest upon rectangular concrete shoes common to the three. These shoes were to be closely fitted within concrete-lined shafts, and were to be supported upon fine sand therein, the intention being to jet the sand from the wells beneath the shoes and so allow each concrete slab to be lowered until it closed off its tunnel portal.

When the coffer dams had been built around these inlet portals and the detritus excavated, it was found that there would be no sound rock at the portals within which the sand-jack wells adjacent to the river could be excavated, and when the designs for reinforced-concrete wells were developed, it was found that such a procedure was prohibitive from a cost standpoint.

Other possible solutions were then examined and a cost estimate was prepared. Several promising solutions were found, which, upon closer investigation, revealed serious defects either from a basis of cost or of operating characteristics or both. Some of these were rather novel. One proposition was to construct an inclined concrete floor extending toward the river side of each portal, with a concrete disk blocked at the top of the incline and released to roll down and close the tunnel inlet, a water cushion being provided to minimize the impact of the rolling disk as it crossed the portal. Because of the great weight and unwieldiness of these disks it was obviously impracticable to try out this scheme prior to the final closure of the tunnels and it was therefore discarded.

Continued investigations revealed that the design finally selected and described herein possessed more of the desirable features sought and fewer of the objectionable characteristics disclosed in the others and it was accordingly selected.

Final detail designs were started at once and the usual quota of unforeseen difficulties began to develop. To make certain closure under the most severe conditions where the water would be ten feet above the top of the tunnel when the leaf started its descent, it was decided that the leaf of each gate should be mounted upon a series of vertically disposed roller trains. These roller trains could be readily designed to carry the 8,600,000-lb water load prevalent under this condition, but it was soon established that they would be excessively large were they to be made capable of carrying the 43,000,000-lb load which would eventually be present when the water in the reservoir stood 300 ft above their sills.

It was then decided to carry the gates down on the roller trains for effecting closure and then to relieve the roller trains of the static water load on the gate by means of a pair of wedges carried on the opposite sides of the gate which would be brought into engagement with fixed wedges built into the tunnel-portal structure.

Computations showed that a downthrust in excess of 5,000,000 lb would be required to seat the wedges under the most adverse conditions, and so relieve the roller trains of

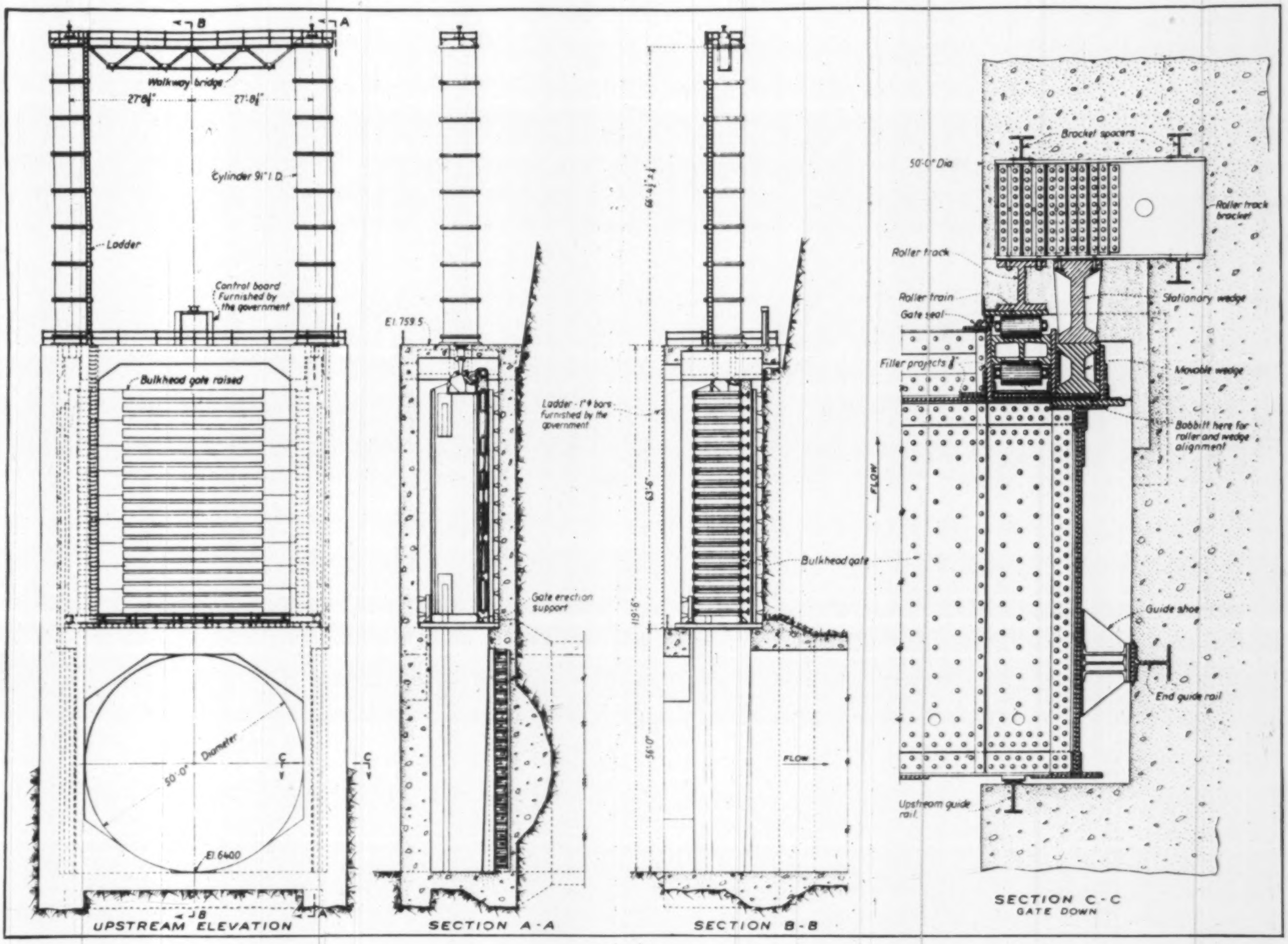
B
A
Walkway bridge
27'8½"
27'8½"
Cylinder 91" I.D.
Ladder
Control board
Furnished by
the government
Bulkhead gate raised
Diameter
50'-0"
C
El. 640.0
B
A
UPSTREAM ELEVATION
El. 759.5
Ladder - 1"ϕ bars
furnished by the
government
Gate erection
support
SECTION A-A
68'-4½"
63'-6"
119'-6"
56'-0"
Bulkhead gate
FLOW
SECTION B-B
Bracket spacers
50'-0" Dia
Roller track
bracket
Roller track
Roller train
Gate seal
Stationary wedge
Filler projects ⅛"
Movable wedge
Babbitt here for
roller and wedge
alignment
FLOW
Guide shoe
End guide rail
Upstream guide
rail
SECTION C-C
GATE DOWN

FIG. 2 GENERAL INSTALLATION ASSEMBLY OF THE BULKHEAD GATE

water loadings. It was then evident that some form of toggle mechanism would have to be employed to accomplish this and it was decided to use the gate-hoisting mechanisms to operate these toggles which could be built into the tops of the gates and used to suspend the gates from their stems. By this arrangement the toggles would be inoperative as long as the gates were suspended, but as soon as the gates were lowered to their closed positions and were supported by their bottom seats, then farther downward movement of their stems would actuate the toggle mechanisms and drive the movable wedges on each side of the gate leaf into engagement with the wedges in the portal faces and so transfer the static water load from the leaves through the wedges and into the portal structure. The wedge-toggle mechanism as finally adopted is shown in the several views given in Fig. 3 where the equipment built into the upper corners of each gate leaf for attaching the stems and for operating the 51-ft movable wedges after closure has been completed may be seen. In Fig. 4 the toggle-body and link castings are shown. These castings constitute parts of the mechanism shown in Fig. 3.

As the designs progressed it became evident that the side girders of the gate leaves and their associated plate members for the wedges and roller trains would be so large and cumbersome when assembled as to make the machining normally required for obtaining uniform bearing a very difficult and expensive operation, yet it was most essential that even distribution of the heavy loadings transferred from the cross girders 55 ft 3 in. long by 12 ft $6^1/_2$ in. deep be provided if a stable structure were to be secured.

This difficulty was finally overcome by providing a pair of relatively light parallel plates with a $^3/_8$-in. space between them into which hard babbitt could be poured after the gates had been completely assembled and their rollerways aligned with carefully leveled straight edges.

The arrangements of these babbitting plates with respect to the vertical and side girders, wedges, and roller ways may be seen in section *C-C* of Fig. 2 and in section *G-G* of Fig. 5, where it will be observed that a series of push-off cap-screws are tapped into the upper plate and can be used to draw them together and hold them in any desired position. Both gate leaves were assembled in the shop in a horizontal position (see Figs. 6 and 7), the plates adjusted to the aligned roller trains and wedges, and then the space filled with molten babbitt. When assembling in the field the roller and wedge assemblies were erected in their vertical positions and bolted to carefully aligned tracks in the upper portions of the portal structures. The cross and vertical girders were then reassembled against them and bolted up tight. Uniform load distribution was thus assured from the gate members to the roller trains and the wedge members. The two top views in Fig. 5 show downstream elevations and end elevations of the wedge and roller train assembly, each of which weighs 76,100 lb. These were each provided with a field joint midway of their vertical heights for convenience in shipping and assembling. This arrangement worked out satisfactorily both for shop fabrication, transportation, and field assembling and resulted in a considerable saving in costs.

The general construction of the roller trains and their com-

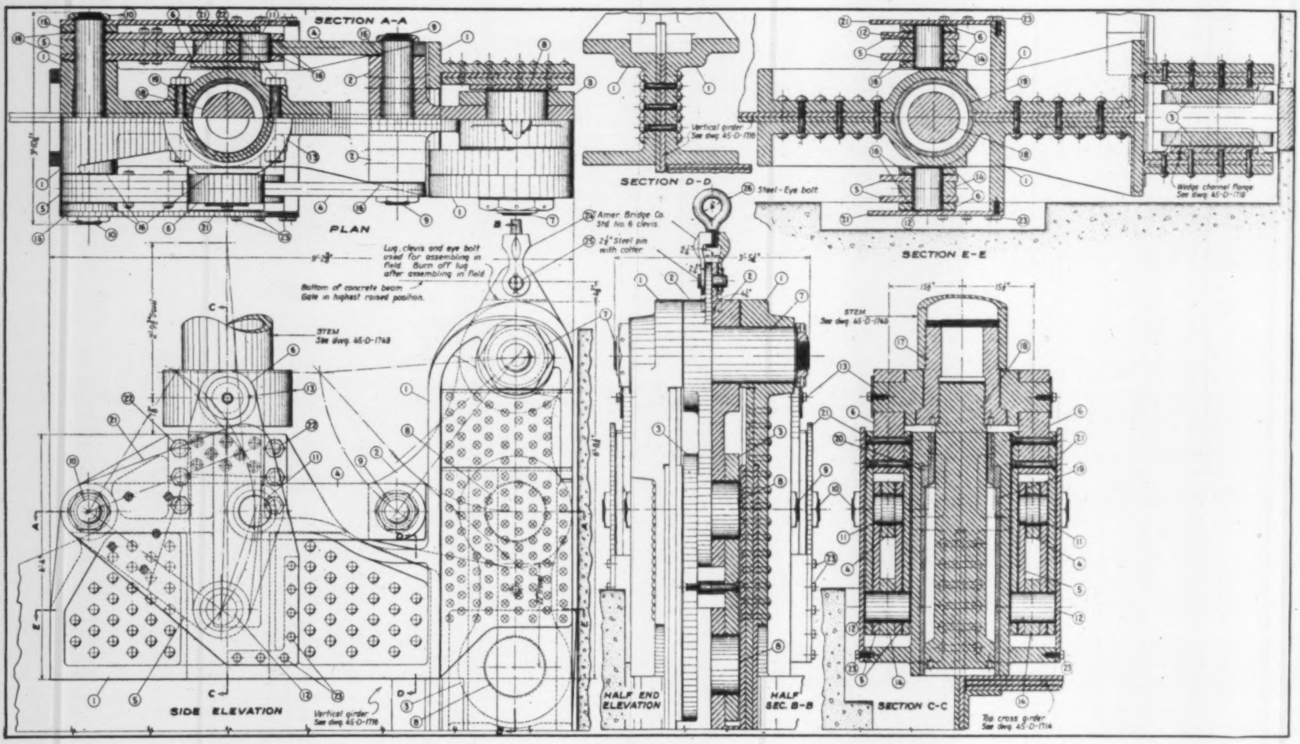
SECTION A-A
PLAN
SECTION D-D
Vertical girder See dwg. 45-D-1718
Steel-Eye bolt
SECTION E-E
Wedge channel flange See dwg. 45-D-1718
Amer. Bridge Co. Std. No. 6 clevis
2½" Steel pin with cotter
Lug, clevis and eye bolt used for assembling in field. Burn off lug after assembling in field
Bottom of concrete beam Gate in highest raised position
STEM See dwg. 45-D-1748
SIDE ELEVATION
Vertical girder See dwg. 45-D-1716
HALF END ELEVATION
HALF SEC. B-B
SECTION C-C
Top cross girder See dwg. 45-D-1714

FIG. 3 WEDGE-TOGGLE MECHANISM ASSEMBLIES

ponent parts is shown in the assemblies and details in Fig. 8. It will be observed that the lower roller trains are made nearly twice as long as the upper roller trains. By doing this and then by properly spacing the roller trains vertically on the gate the horizontal water load on the upstream face is distributed in nearly uniform amounts per inch of roller face in all the rollers throughout the height of the gate.

The roller ways and end pieces are steel castings, the links are alloy cast steel, the pins are rolled manganese bronze, and the rollers are "Mehanite" iron, ground on their cylindrical surfaces to very close tolerances.

The detail construction of the cast-steel fixed wedges which are bolted to the portal structures and the movable wedges carried on each side of the gate leaves is shown in Fig. 9, and in Fig. 10 two main units of the fixed wedges are seen being machined. In Fig 11 the top portion of a movable-wedge unit is being faced in an open-side planer. The steel casting shown is 16 ft 6 in. long and the complete wedge is 50 ft 10 in. long overall and weighs 23,900 lb.

In Fig. 12 the detail assembly of the gate leaf, complete with the toggle mechanisms, movable wedges, roller trains, guide shoes, and associated parts, is illustrated. The relationship of the wedge and toggle mechanisms is shown in the end elevation, the arrangement of the roller trains is seen in section *A-A*, and the relative positions of the skin-plate units and of the bottom seat are given in section *C-C*.

FIG. 4 TOGGLE BODY AND LINK CASTINGS IN BOULDER CITY YARDS

(In the background hoist-cylinder castings are seen, while beyond are the bare, rocky hills.)

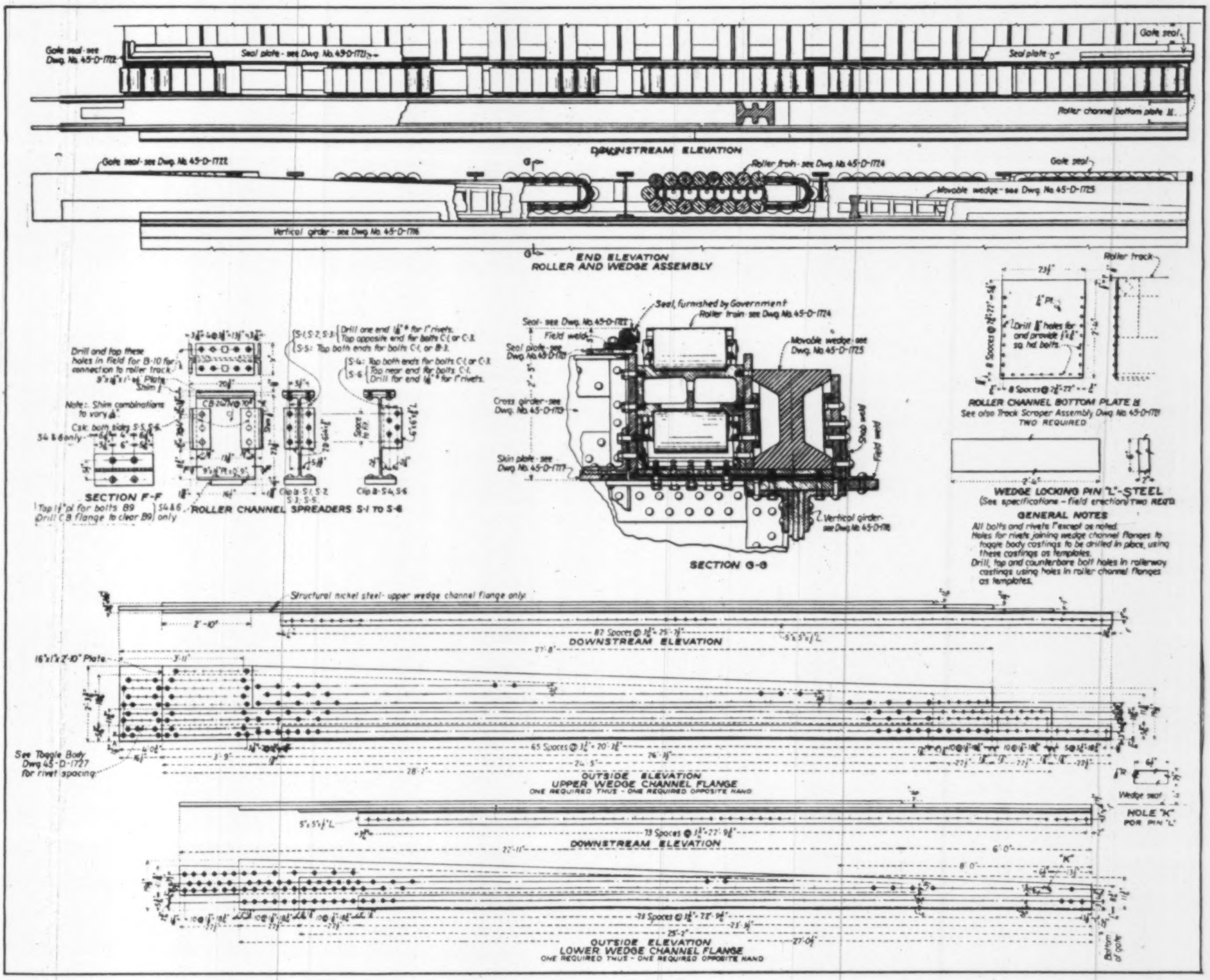
Gate seal - see Dwg. No. 45-D-1722
Seal plate - see Dwg. No. 45-D-1721
Gate seal
Seal plate
Roller channel bottom plate M
DOWNSTREAM ELEVATION
Gate seal - see Dwg. No. 45-D-1722
Roller train - see Dwg. No. 45-D-1724
Gate seal
Movable wedge - see Dwg. No. 45-D-1725
Vertical girder - see Dwg. No. 45-D-1716
END ELEVATION
ROLLER AND WEDGE ASSEMBLY
Drill and tap these holes in field for B-10 for connection to roller track
Shim
Note: Shim combinations to vary
Csk. both sides S-5, S-6
SECTION F-F
Tap pl for bolts B9 / Drill CB flange to clear B9 — S4 & 6 only
S-1, S-2, S-3: Drill one end for 1" rivets. Tap opposite end for bolts C-1 or C-3.
S-5: Tap both ends for bolts C-1, or B-3.
S-4: Tap both ends for bolts C-1 or C-3.
S-6: Tap near end for bolts C-1. Drill for end for 1" rivets.
Clip S-1, S-2, S-3, S-5
Clip B-S-4, S-6
ROLLER CHANNEL SPREADERS S-1 TO S-6
Seal, furnished by Government
Roller train - see Dwg. No. 45-D-1724
Seal - see Dwg. No. 45-D-1722
Field weld
Seal plate - see Dwg. No. 45-D-1721
Movable wedge - see Dwg. No. 45-D-1725
Cross girder - see Dwg. No. 45-D-1713
Skin plate - see Dwg. No. 45-D-1717
Shop weld
Field weld
Vertical girder - see Dwg. No. 45-D-1716
SECTION G-G
Roller track
Drill holes for and provide sq. hd. bolts
ROLLER CHANNEL BOTTOM PLATE M
See also Track Scraper Assembly Dwg. No. 45-D-1701
TWO REQUIRED
WEDGE LOCKING PIN "L" - STEEL
(See specifications - field erection) TWO REQ'D
GENERAL NOTES
All bolts and rivets 1" except as noted.
Holes for rivets joining wedge channel flanges to toggle body castings to be drilled in place, using these castings as templates.
Drill, tap and counterbore bolt holes in rollerway castings using holes in roller channel flanges as templates.
Structural nickel steel - upper wedge channel flange only
87 Spaces
DOWNSTREAM ELEVATION
16"x1"x2'-10" Plate
See Toggle Body Dwg. 45-D-1727 for rivet spacing
65 Spaces
OUTSIDE ELEVATION
UPPER WEDGE CHANNEL FLANGE
ONE REQUIRED THUS - ONE REQUIRED OPPOSITE HAND
Wedge seat
HOLE "K" FOR PIN "L"
73 Spaces
DOWNSTREAM ELEVATION
39 Spaces
OUTSIDE ELEVATION
LOWER WEDGE CHANNEL FLANGE
ONE REQUIRED THUS - ONE REQUIRED OPPOSITE HAND

FIG. 5 ROLLER AND WEDGE-CHANNEL ASSEMBLIES AND SECTIONS

In the final designs for the gate leaf no allowance was made for corrosion due to the relatively short time that these gates will be in actual service, and to the fact that when final closure has once been made they will necessarily remain as a fixed part of the associated structures and, in consequence, will not be salvageable. With these conditions in mind it was decided to run the maximum combined stresses up close to 20,000 lb per sq in.

By reference to Fig. 12 it will be seen that the gate leaf consists of a framework composed of 19 horizontal cross girders framed into vertical girders at either side. The cross girders are 55 ft 3 in. long by 12 ft $6^1/_2$ in. deep and weigh 64,100 lb each. The two vertical girders are 52 ft $1^1/_2$ in. high by 10 ft $6^1/_2$ in. deep and weigh 68,400 lb each.

The major portion of the upstream face of the gate leaf is enclosed by the upstream cover plates consisting of 1-in. plates covering a space 23 ft 6 in. wide on either side of the vertical centerline of the gate and extending upward for 50 ft 6 in. of the gate's height, with supplemental plates, each $^7/_8$ in. thick by 24 in. wide, extending 16 ft $^1/_2$ in. on either side of the vertical centerline of the gate. The details of these plates are shown in Fig. 13. The arrangement of these cover plates is such as not only to provide the essential supplemental girder flange areas, but also to space and support effectively the heavy horizontal girders at their upstream flanges and to aid in carrying the vertical water load on the top of the gate down to the bottom gate seat when the leaf is in the closed position.

By reference to sections *A-A* and *B-B* of Fig. 12 it will be seen that vertical stiffeners have been provided between the girder web plates to space them and give them lateral support about midway between their upstream and downstream flange faces.

Seventeen of the cross girders were made alike for each leaf in accordance with the details as shown in Fig. 14, while the top and bottom girders were altered to receive the upper and lower sealing members in the general manner as indicated in section *C-C* of Fig. 12. Sections *D-D* to *H-H*, inclusive, also details *J* and *L*, show the 8-in. by $3^1/_2$-in. by $^5/_8$-in. angles riveted and welded in the shop in aligned pairs on opposite sides of the girder webs. To the outstanding 8-in. legs of these angles the skin-plate units are riveted in the field.

In Fig. 15 the general views and sections show the details of construction of the vertical girders to which the end flanges of all the cross girders are riveted, and to the upper web-plate extensions of which the toggle mechanisms are likewise attached by heavy riveting. In this figure the heavily reinforced webs and downstream flanges which transfer the loads received from the cross girders to the roller trains and wedges

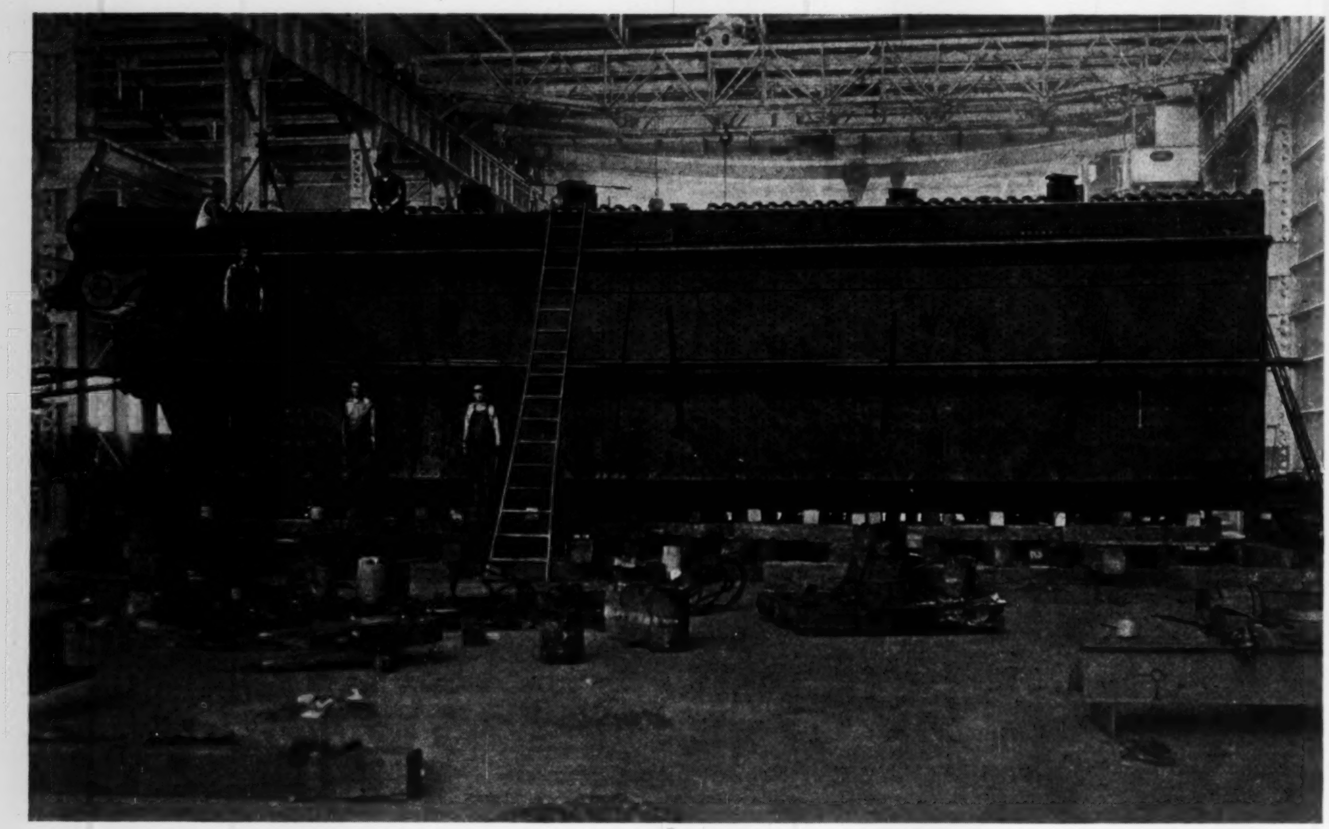

FIG. 6 BULKHEAD-GATE LEAF NEARING COMPLETION IN CONSOLIDATED STEEL COMPANY'S SHOPS
(Portions of the roller trains are visible above the top edge of the gate and a toggle body and link are shown in place at the left of the picture.)

are shown. Here we have the rather unusual condition of a deep and heavy plate girder without any web stiffeners, the explanation being that the connecting flanges of the cross girders will perform this office when they are assembled and riveted to these vertical girders.

The cross girders are spaced 30 in. apart vertically at the bottom of the leaf and this dimension is uniformally increased as the next succeeding girders above are installed until this spacing reaches a maximum of 35 in., center to center, at the top of the leaf. By this arrangement the horizontal water load on each girder is maintained approximately the same.

The bending stresses in the cross girders were determined by using the moment of inertia of the whole section after deducting the rivet holes in the tension flanges. The skin plates and cover plates were considered as being part of the girder flanges.

The web shearing stresses were determined on a basis of the gross web areas of the girders.

The cover plates and the skin plates will be subjected to a direct vertical stress due to the weight of the gate and the superimposed water load on the top of the gate. It was these last two vertical loadings which made the design of the skin-plate units a difficult and vexatious problem, for these parts were already subjected to severe horizontal tensile stresses produced by the flexure of the horizontal girders under load and to direct bending stresses in a vertical plane due to the horizontal water loads upon their upstream vertical faces.

These skin-plate panels or units are placed between the webs of the cross girders 24 in. back from the downstream flange faces of these girders and extend across the full width of the gate from one vertical girder to the other. They are aligned vertically one above another in the manner shown in section *C-C* of Fig. 12. The details of their construction and connections to the web plates of the cross girders are shown in large scale in Fig. 16. The 8-in. by $3^1/_2$-in. by $^5/_8$-in. angles on the upstream or left-hand side of the skin-plate units are riveted and welded in the shop to the cross-girder webs. The vertical legs are riveted in the field to the skin plates and to the 8-in. by 8-in. by $^1/_2$-in. angles, whose horizontal legs are also riveted in the field to the cross-girder webs.

By inspection of detail *J* and detail *L* of Fig. 14 and also the construction illustrated in Fig. 16, it will be seen that the 8-in. by $3^1/_2$-in. by $^5/_8$-in. angles which are riveted in the shop to the cross girders are also welded to the girders, and that the downstream corners of these angles are planed at an angle 30 deg to the planes of the 8-in. legs of these angles, and that the adjacent edges of the $^5/_{16}$-in. plates on each side of the center $^7/_8$-in. web plate are also planed as shown in details *J* and *L* of Fig. 14. Thus a parallel-sided gap about $^3/_8$ in. wide is provided to receive the deposited weld metal.

This arrangement served a dual purpose: The first to anchor the corners of these angles effectively to the $^7/_8$-in. web plates of the cross girders throughout the widths of the gates, and at the same time so to place the deposited weld metal as to produce the least possible interference with the skin plates; the second to provide an effective water seal so that all water would be shut off from further intrusion between the center web plates and the $^5/_{16}$-in. plates beyond where the skin-plate units would be installed. This arrangement saved much field welding in cramped and difficult quarters and made for stronger and more reliable construction.

The upper and lower upstream edges of the skin-plate units are beveled to clear the weld fillets holding the downstream angle corners to the cross-girder web plates, and the upper and lower edge faces of the skin plates were accurately planed to

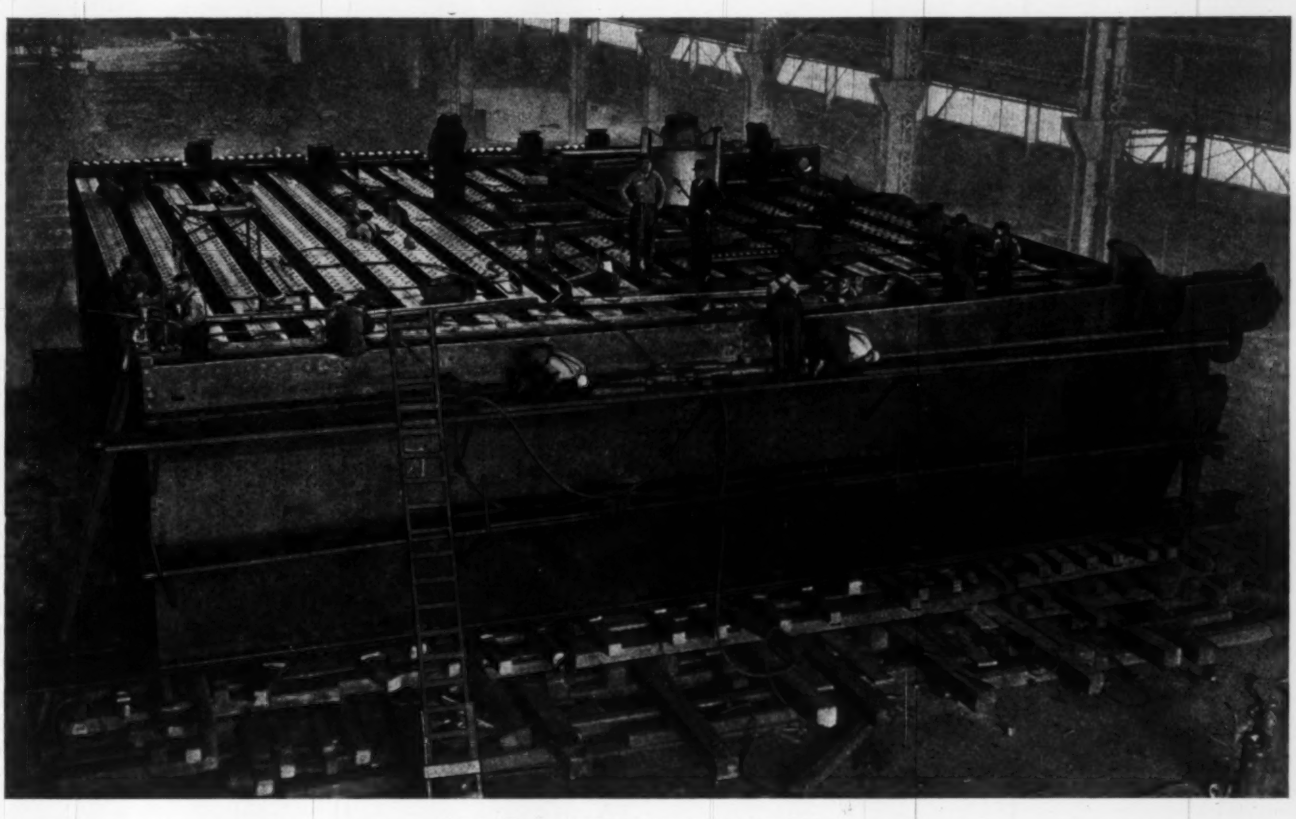

FIG. 7 NEARLY COMPLETED GATE LEAF

(Midway of the gate's breadth three men can be seen working between the cross-girder flanges. There are 19 men on the gate in this picture.)

proper widths to give bearing against the cross-girder web plates. The 8-in. by 8-in. by $^1/_2$-in. angles on the downstream sides of the skin plates were accurately fitted in place in the completely assembled gates in the shop and then stitch-riveted to their skin plates so as to avoid interference with the angles riveted to the webs of the cross girders.

The construction illustrated in Fig. 16 is the result of many trials and is derived from the best features of a number of solutions worked out to take care of a set of conditions which, as one engineer remarked, "were rather exasperating."

By this arrangement the skin-plate units supported by the cross-girder webs have alternate thick and thin sections, with the thick sections adjacent to the cross-girder webs and the thin sections in their mid portions. Their thick sections, consisting of the skin plate plus the angle legs on their upstream and downstream faces, were considered as having no deflection at the girder supports and as terminating at the outer edges of the rivet heads nearest the edges of the angle legs. The thin sections lie between the terminations of these thick sections and are of the skin-plate thickness. When calculating the skin-plate bending stresses due to direct water load, the equations given in Fig. 16 were employed, and combined stresses due to the additional vertical loadings caused by the weight of the gate and the superimposed water load transmitted to the bottom seat from above and the horizontal tensile stresses produced by the flexure of the horizontal girders were obtained by adding colinear stresses algebraically and the cross stresses, multiplied by Poisson's ratio of 0.3 with changed signs.

The stresses were worked out and tabulated for the critical points in all of the 19 girders and in the skin-plate panels. The maximum combined stresses in no instance exceeded the prescribed limit of 20,000 lb per sq in.

Calculations were made to determine the deflection of the leaf at the critical girder, with accompanying angular deflections at the supports, and it was found that the leaf would deflect 0.253 in. on its vertical centerline (centerline of gate leaf) and that the angular deflections at the wedge faces on either side of the gate leaf would be 0 deg, 05 min., and 00 sec.

Similar calculations were made for the leaf when being closed with 60-ft head above the sills and the leaf supported on the roller trains prior to setting the wedges into final position by means of the toggles. It was found that the deflection at the middle of the gate's width would be 0.023 in. and that the angular deflection of the roller trains on each side of the gate would be 0 deg, 00 min, and 48 sec.

The rollers have 14-in. faces, and with the computed angular deflection they would move 0.00165 in., which a slight powdering of the concrete behind their tracks would accommodate. In section *C-C* of Fig. 2 the relative positions of the rollers, roller tracks, fixed and movable wedges, seals, and the embedded reinforcing beams in the concrete portal face are shown in large scale with respect to the gate leaf, and the conditions of deflection just described will be understood more readily by reference thereto. Originally, it had been planned to coat the concrete faces of the tracks with an elastic, bituminous material which would compress and so permit the requisite movement necessary to accommodate the varying angular displacements produced by the deflecting movements of the gate leaf when under loads of varying water levels, but this was hazardous on account of blowouts and so, after painstaking investigations and many consultations, it was decided to allow the concrete to powder sufficiently to accommodate responsive deflections of the tracks.

The roller tracks on which the endless roller trains will rest as the gates are lowered to their closed positions are built-up

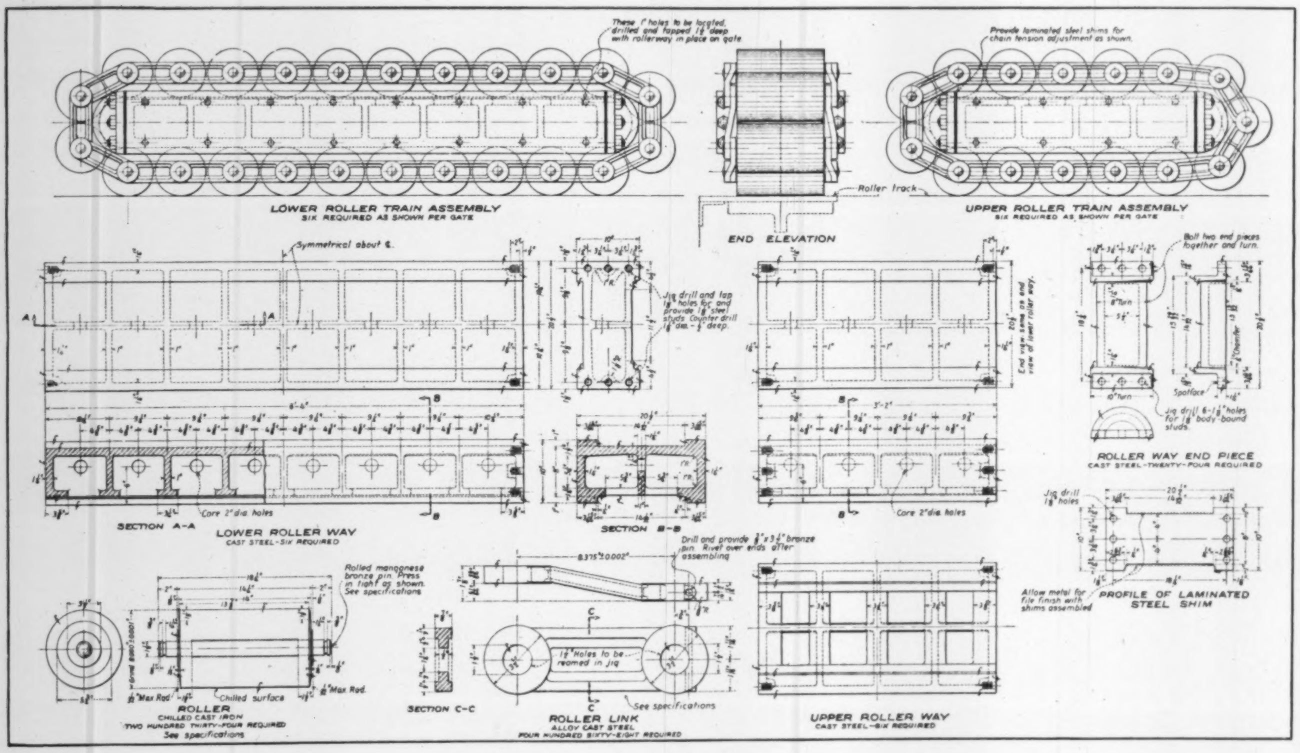
These 1" holes to be located, drilled and tapped 1⅛" deep with rollerway in place on gate
Provide laminated steel shims for chain tension adjustment as shown.
Roller track
LOWER ROLLER TRAIN ASSEMBLY
SIX REQUIRED AS SHOWN PER GATE
END ELEVATION
UPPER ROLLER TRAIN ASSEMBLY
SIX REQUIRED AS SHOWN PER GATE
Symmetrical about ℄.
Jig drill and tap 1⅛" holes for and provide 1⅛" steel studs. Counter drill 1⅛" dia. - ½" deep.
End view same as end view of lower roller way.
Bolt two end pieces together and turn.
8"Turn
10"Turn
Spotface
Chamfer
Jig drill 6-1⅛" holes for 1⅛" body-bound studs.
6'-4"
3'-2"
20½"
Core 2" dia. holes
SECTION A-A
LOWER ROLLER WAY
CAST STEEL-SIX REQUIRED
SECTION B-B
Core 2" dia. holes
ROLLER WAY END PIECE
CAST STEEL-TWENTY-FOUR REQUIRED
Jig drill 1⅛" holes
Drill and provide ⅞" x 3½" bronze pin. Rivet over ends after assembling
8.375"±0.002"
Rolled manganese bronze pin. Press in tight as shown. See specifications
Max Rad.
Chilled surface
ROLLER
CHILLED CAST IRON
TWO HUNDRED THIRTY-FOUR REQUIRED
See specifications
SECTION C-C
1⅞" Holes to be reamed in jig
See specifications
ROLLER LINK
ALLOY CAST STEEL
FOUR HUNDRED SIXTY-EIGHT REQUIRED
UPPER ROLLER WAY
CAST STEEL-SIX REQUIRED
Allow metal for file finish with shims assembled
PROFILE OF LAMINATED STEEL SHIM

FIG. 8 ROLLER-TRAIN ASSEMBLIES AND PARTS

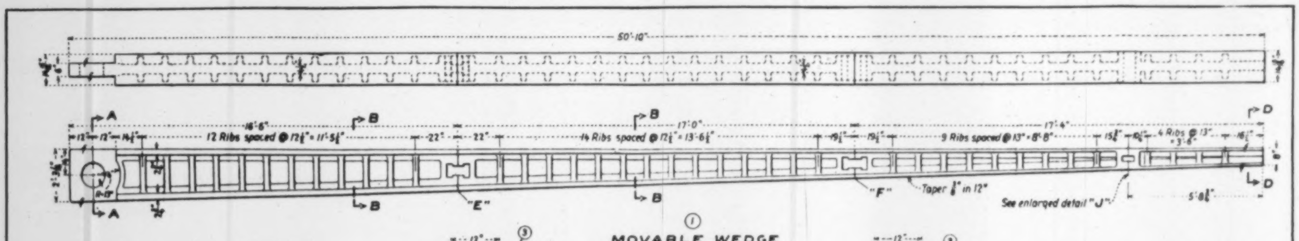
50'-10"
16'-6"
17'-0"
17'-4"
12 Ribs spaced @ 12½" = 11'-5½"
14 Ribs spaced @ 12½" = 13'-6½"
9 Ribs spaced @ 13" = 8'-8"
4 Ribs @ 13" = 3'-8"
22"
"E"
"F"
Taper ⅛" in 12"
See enlarged detail "J"
5'-8⅛"
①
MOVABLE WEDGE
CAST STEEL - TWO REQUIRED
SECTION A-A
TYPICAL SECTION B-B
SECTION C-C
Peen small end of pin to fit countersink. Grind both ends flush when assembled in field.
Csk ⅛"
DETAIL AT SPLICE "E"
2¼" x 6¼" Hole for pin "L" on Dwg 45-D-1719
DETAIL AT "J"
DETAIL AT SPLICE "F"
SECTION D-D
Drill 1⅛" holes
51'-4"
For base plate see Dwg. No. 45-D-1733 detail 24
19'-11"
16'-11½"
14'-5½"
12 Spaces @ 13½" = 13'-6"
4 Spc @ 13" = 4'-4"
7 Spaces @ 13" = 7'-7"
9 Spaces @ 12½" = 9'-4½"
10 Spaces @ 12" = 10'-0"
Taper ⅛" in 12"
Drill 1⅛" holes
1⅞" Cored holes
11 Spaces @ 12½" = 11'-5½"
12 Spaces @ 13" = 13'-0"
13'-11½"
12'-11"
②
STATIONARY WEDGE
CAST STEEL - TWO REQUIRED
Drill 1⅛" holes, core 2¼" R and spotface 2¼" D inside.
TYPICAL SECTION G-G
Drill 1⅛" holes
Core 2¼" R
TYPICAL SECTION H-H
"L"
Taper ⅛" per foot
④
TAPER PIN
STEEL - TWO REQUIRED "L" = 21⅛"
TWO REQUIRED "L" = 14⅜"
Finish all over
Drill for 1⅛" taper pin ④ after assembling
③
SPLICE KEY
STEEL - FOUR REQUIRED
Finish all over to fit movable wedge

FIG. 9 STATIONARY AND MOVABLE WEDGES

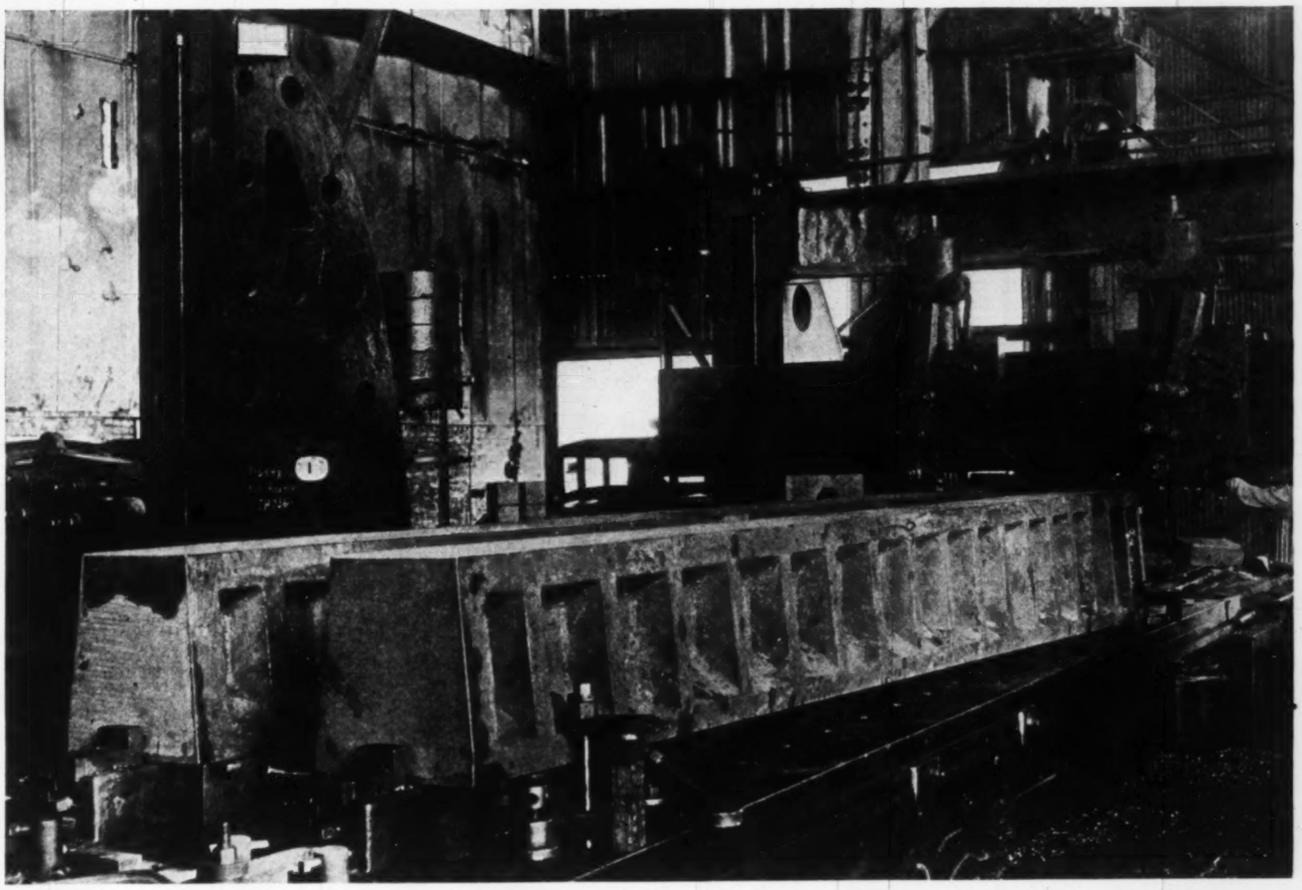

FIG. 10 STATIONARY-WEDGE UNITS BEING MACHINED

members consisting of Carnegie H-sections, $16^3/_4$ in. high and weighing 320 lb per ft. The high-carbon-steel plates 22 in. wide by 1 in. thick are riveted with countersunk heads to the H-sections and the plates are then machined. This construction provides very stiff and rigid tracks of sufficient breadth to receive the vertical seal contacts as well.

In Fig. 17, section *B-B* shows a detail cross-section through one of these roller tracks. In Fig. 18 two of these roller-track members are shown resting on grillage beams in the erection bay of the Consolidated Steel Company's shops. These track members were spaced parallel on approximately 50-ft centers and their upturned finished track surfaces carefully aligned and leveled into a common plane on which the cross girders of a gate leaf were then assembled in the manner shown in Fig. 19. In Fig. 18 the erection crew is seen preparing the grillage of beams to form the foundation for supporting the

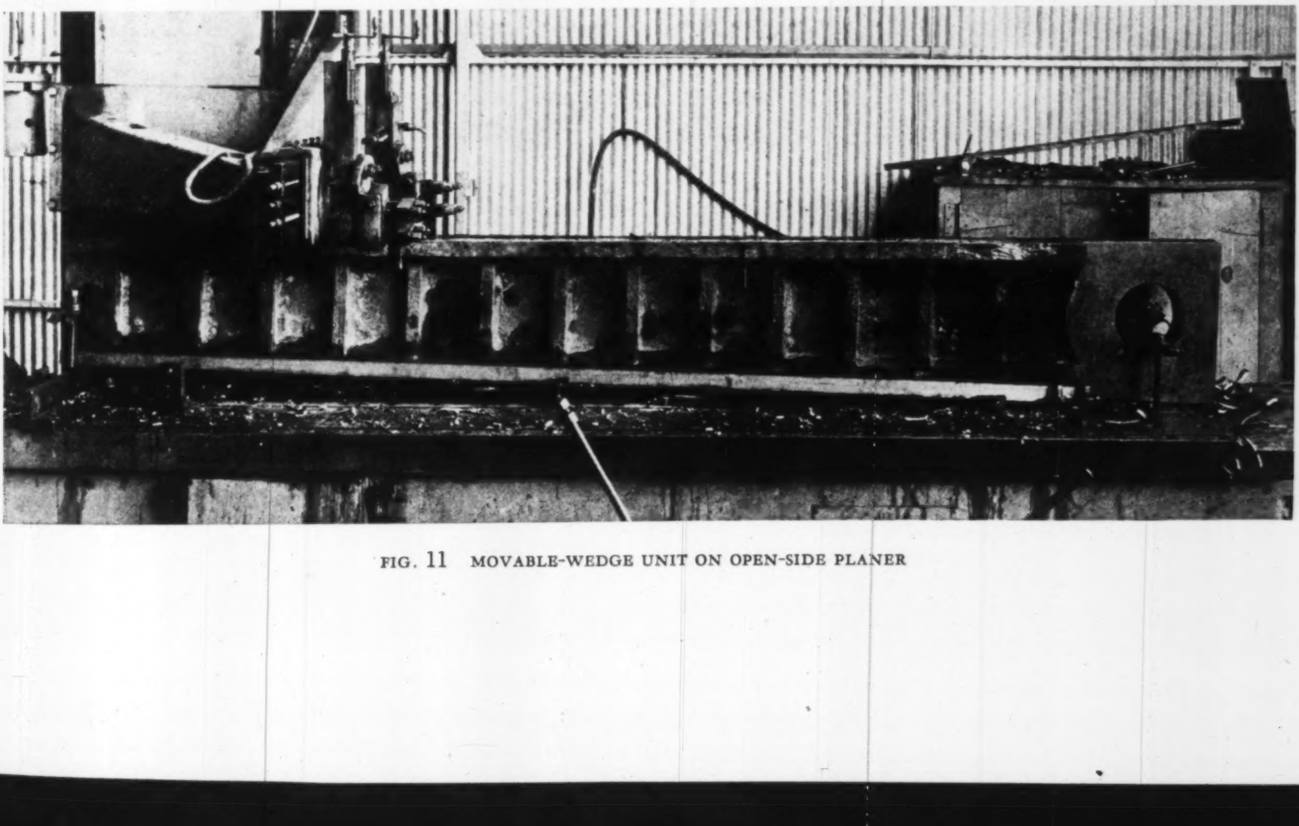

FIG. 11 MOVABLE-WEDGE UNIT ON OPEN-SIDE PLANER

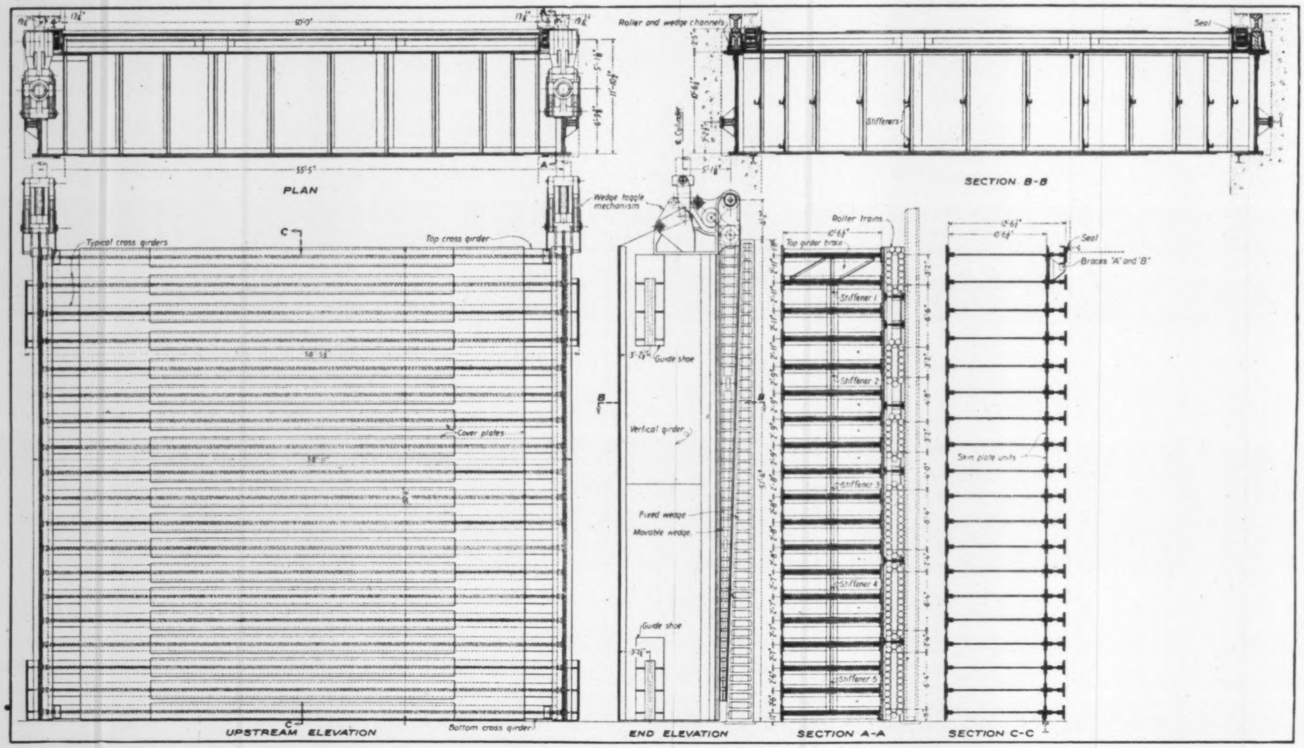
Roller and wedge channels
Seal
Stiffeners
PLAN
SECTION B-B
Cylinder
Wedge toggle mechanism
Typical cross girders
Top cross girder
Roller trains
Top girder brace
Braces "A" and "B"
Stiffener 1
Stiffener 2
Stiffener 3
Stiffener 4
Stiffener 5
Guide shoe
Vertical girder
Cover plates
Skin plate units
Fixed wedge
Movable wedge
Bottom cross girder
UPSTREAM ELEVATION
END ELEVATION
SECTION A-A
SECTION C-C

FIG. 12 GATE-LEAF ASSEMBLY AND SECTIONS

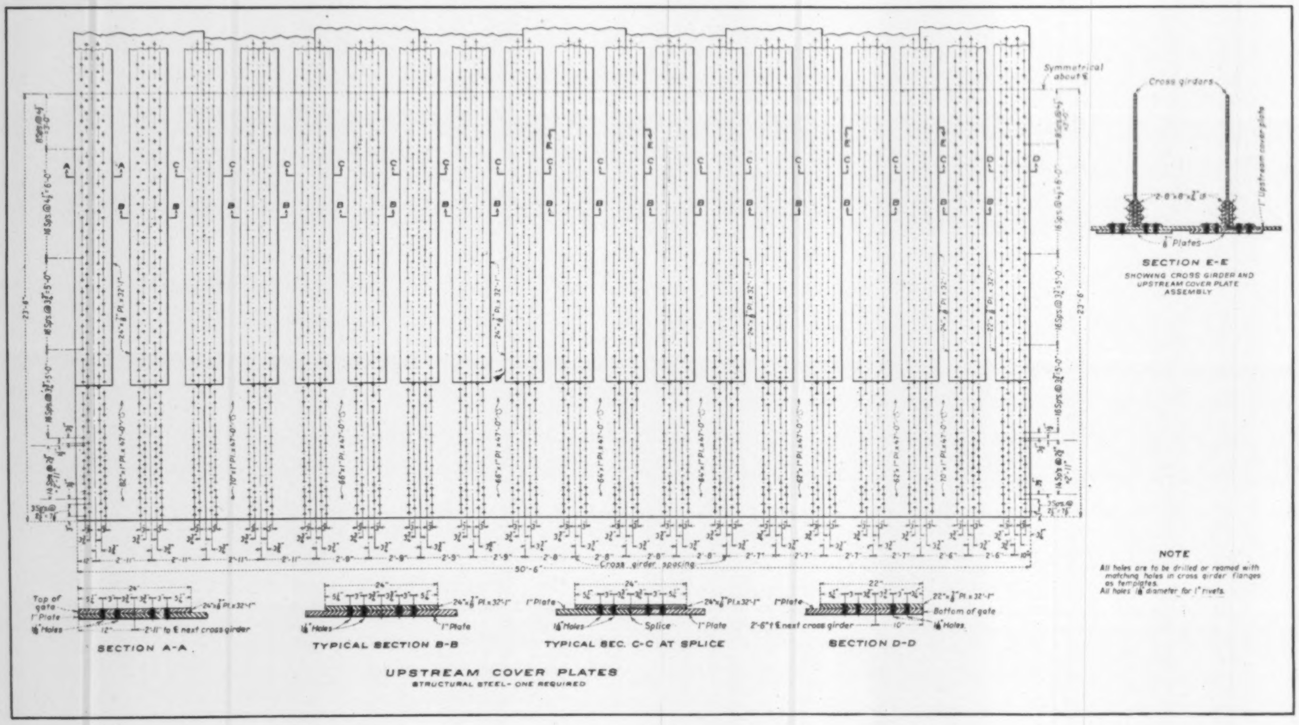
Symmetrical about ℄
Cross girders
Upstream cover plate
Plates
SECTION E-E
SHOWING CROSS GIRDER AND UPSTREAM COVER PLATE ASSEMBLY
Cross girder spacing
NOTE
All holes are to be drilled or reamed with matching holes in cross girder flanges as templates.
All holes 1 1/16 diameter for 1" rivets.
Top of gate
1" Plate
Holes
Splice
Bottom of gate
SECTION A-A
TYPICAL SECTION B-B
TYPICAL SEC. C-C AT SPLICE
SECTION D-D
UPSTREAM COVER PLATES
STRUCTURAL STEEL- ONE REQUIRED

FIG. 13 UPSTREAM COVER PLATES

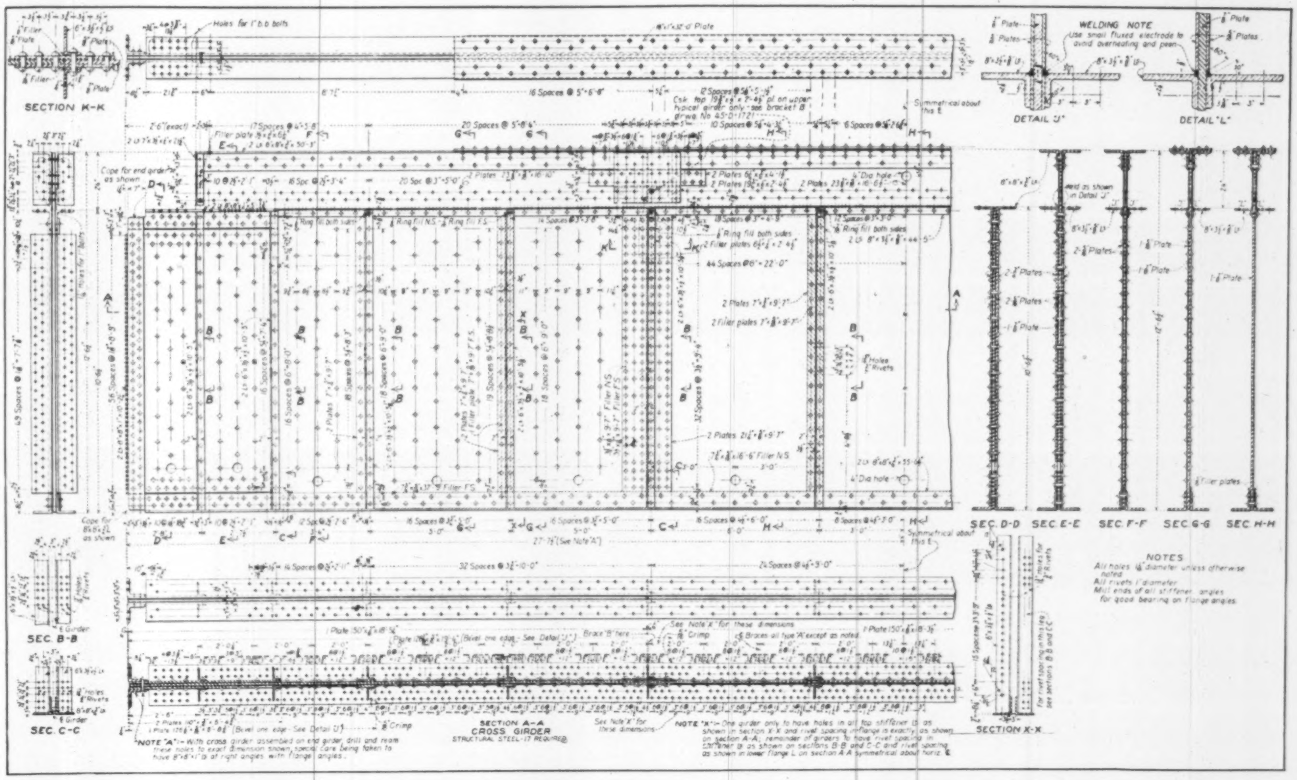
SECTION K-K
WELDING NOTE
Use small fluxed electrode to avoid overheating and peen
DETAIL "J"
DETAIL "L"
SEC. D-D
SEC. E-E
SEC. F-F
SEC. G-G
SEC. H-H
NOTES
All holes 1 1/16" diameter unless otherwise noted
All rivets 1" diameter
Mill ends of all stiffener angles for good bearing on flange angles.
SEC. B-B
SEC. C-C
SECTION A-A
CROSS GIRDER
STRUCTURAL STEEL-17 REQUIRED
SECTION X-X
NOTE "A":- With cross girder assembled on end girder, drill and ream these holes to exact dimension shown, special care being taken to have 8"×8"×1" Ls at right angles with flange angles.
NOTE "X":- One girder only to have holes in all top stiffener Ls as shown in section X-X and rivet spacing in flange is exactly as shown on section A-A; remainder of girders to have rivet spacing in stiffener Ls as shown on sections B-B and C-C and rivet spacing as shown in lower flange L on section A-A symmetrical about horiz. ℄

FIG. 14 TYPICAL CROSS GIRDER

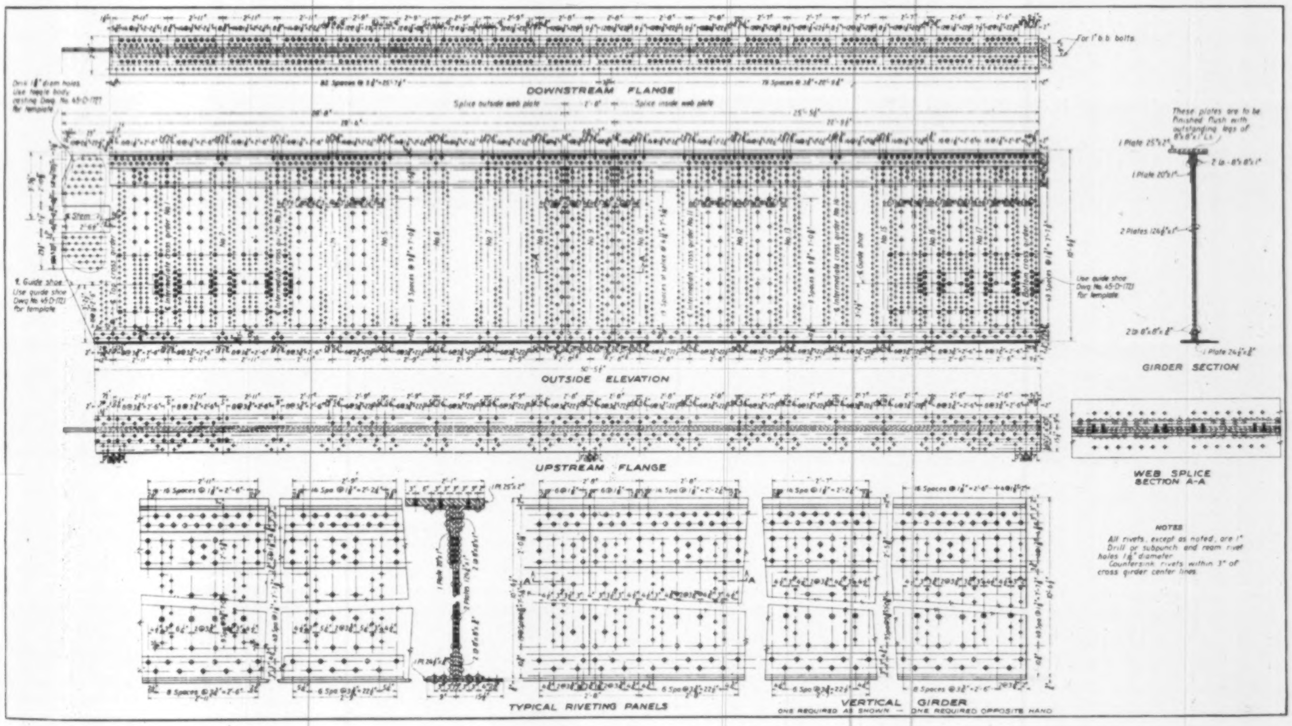
DOWNSTREAM FLANGE
OUTSIDE ELEVATION
UPSTREAM FLANGE
GIRDER SECTION
WEB SPLICE
SECTION A-A
NOTES
All rivets, except as noted, are 1"
Drill or subpunch and ream rivet holes 1 1/16" diameter
Countersink rivets within 3" of cross girder center lines.
TYPICAL RIVETING PANELS
VERTICAL GIRDER
ONE REQUIRED AS SHOWN — ONE REQUIRED OPPOSITE HAND

FIG. 15 VERTICAL-GIRDER ASSEMBLY

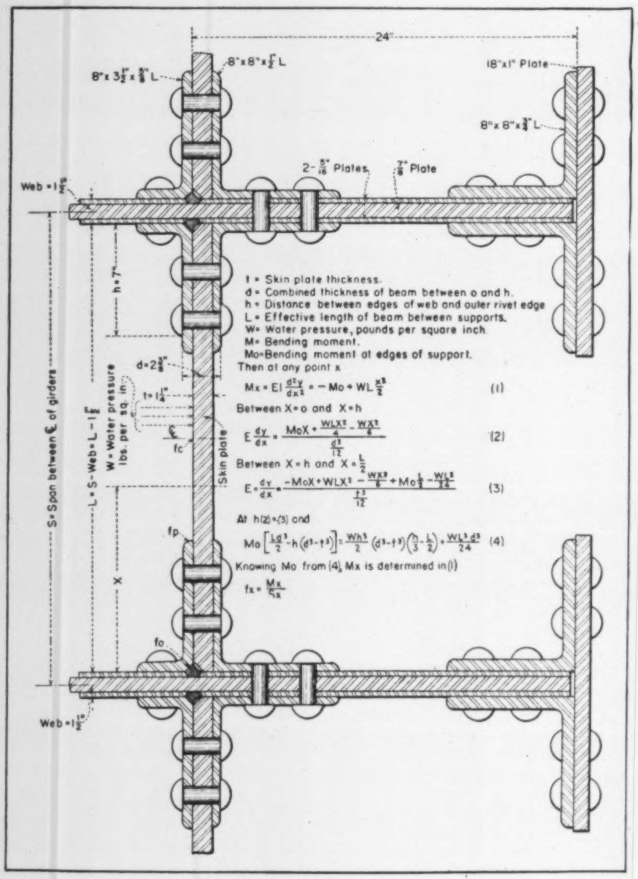
24"
8"x 3½"x ⅝" L
8"x 8"x ⅝" L
18"x1" Plate
8"x 8"x ¾" L
2-5/16" Plates
7/8" Plate
Web = 1½"
h = 7"
t = Skin plate thickness.
d = Combined thickness of beam between o and h.
h = Distance between edges of web and outer rivet edge
L = Effective length of beam between supports.
W = Water pressure, pounds per square inch
M = Bending moment.
Mo = Bending moment at edges of support.
Then at any point x
$M_x = EI\frac{d^2y}{dx^2} = -M_o + WL\frac{x^2}{2}$ (1)
Between X = o and X = h
$E\frac{dy}{dx} = \frac{M_oX + \frac{WLX^2}{4} - \frac{WX^3}{6}}{\frac{d^3}{12}}$ (2)
Between X = h and X = $\frac{L}{2}$
$E\frac{dy}{dx} = \frac{-M_oX + WLX^2 - \frac{WX^3}{6} + M_o\frac{L}{2} - \frac{WL^3}{24}}{\frac{t^3}{12}}$ (3)
At h (2) = (3) and
$M_o\left[\frac{Ld^3}{2} - h(d^3 - t^3)\right] = \frac{Wh^3}{2}(d^3 - t^3)\left(\frac{h}{3} - \frac{L}{2}\right) + \frac{WL^3d^3}{24}$ (4)
Knowing Mo from (4), Mx is determined in (1)
$f_x = \frac{M_x}{S_x}$
d = 2⅜"
t = 1¼"
W = Water pressure lbs. per sq. in.
℄
fc
Skin plate
S = Span between ℄ of girders
L = S - Web = L - 1½"
X
fp
fo
Web = 1½"

FIG. 16 SKIN-PLATE ASSEMBLY WITH ACCOMPANYING EQUATIONS

first leaf as its members are assembled as just described. The two H-beams whose ends face the camera are the roller-track members on which the gates will ultimately roll down to final closure after being installed at the dam-site. High-carbon-steel plates are riveted to the upper flanges of these beams and the top faces of these plates are placed parallel on about 50-ft centers. Their upturned finished faces are accurately leveled and aligned to a common plane by means of the transit set-up seen in the right center background of this picture. By this arrangement the main members of the gate leaves were assembled in their correct positions and in accurate alignment, and the work of erecting, fitting, and assembling was accomplished with greater precision and facility than would have otherwise been secured.

In Fig. 19 the first three cross girders have been set in place on the two roller-track members. The lifting beam and hook block of the overhead crane setting the near cross girder are seen in the upper foreground, while the man standing on the upstream cover plate gives an idea as to the depth of these 64,000-lb members.

The gate leaves were completely assembled in a horizontal position in the shop with their downstream sides facing upward, and their roller-train and wedge-channel assemblies were then installed. (See Fig. 5.) The push-off capscrews shown in section *G-G* were then adjusted to provide about $^3/_8$-in. space between the upper face of the babbitting plates resting upon the cross-girder and vertical-girder flanges and the under face of the adjacent plates forming the back of the wedge and roller-train channels. In Fig. 6 a gate leaf is seen nearing completion in the Consolidated Steel Company's shops in Los Angeles. The toggle-body castings and toggle link are seen at the upper left of the picture which shows the leaf lying on its upstream face. Portions of the endless-track roller trains can be seen along its upper edge. Note the ladder

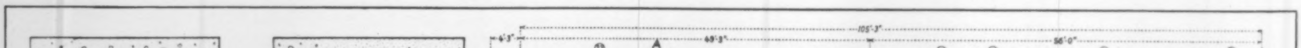
SECTION A-A
FLOW
SECTIONAL PLAN AT ℄ TUNNEL
NOTES
All rivets ⅞" and open holes 15/16" except as noted.
Guide rails and roller tracks shall be furnished straight and true.
Furnish about 5 per cent more bolts and capscrews than shown on drawings
Roller track
Semisteel chair
End guide rail
℄ Wedge
Top gate seal
Symmetrical about ℄ of Tunnel
Bottom gate seal
Upstream guide rail
UPSTREAM ELEVATION
Roller track
℄ Wedge
SECTION B-B (ENLARGED)
Upstream guide rail
End guide rail
Semisteel chair
10 Spaces @ 5'-0" = 50'-0"
12 Spaces @ 4'-1" = 49'-0"
SIDE ELEVATION

FIG. 17 GATE-FRAME ASSEMBLY AND SECTIONS

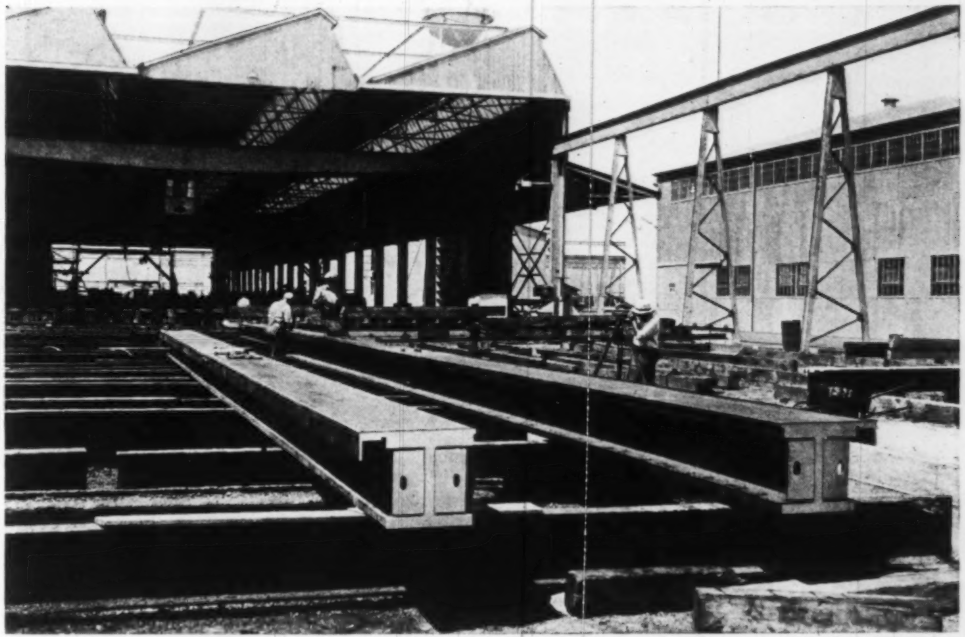

FIG. 18 SETTING BEARING GIRDERS AND LEVELING BEAMS IN PREPARATION FOR ASSEMBLING FIRST BULKHEAD GATE LEAF

(Two heavy roller-track members extend toward camera.)

and the two parallel levels of timber staging giving access to the vertical rows of holes for the cross-girder flange connections. Sections of the finished and rigid roller tracks were then laid with their machined faces turned down upon the series of upward-facing roller trains seen in Fig. 6, and were thus employed as straight edges to level and align these members by manipulation of the push-off and hold-down capscrews until all the roller trains and the wedge surfaces had been brought into a common level plane. Thereupon the drilling and reaming of the holes for the body-bound bolts were completed and these were then pulled up tight to hold all the parts in rigid engagement. In Fig. 7 the shop assembly crew is shown engaged in this reaming and fitting work. The spaces between the babbitting plates were then poured full of molten babbitt. The nearly completed leaf with the workmen busy at their tasks, as seen in Fig. 7, gives a good idea of its general construction and size. Midway of the gate's breadth three men can be seen working in the spaces between the cross-girder flanges fitting up the skin-plate units. Along its far edge the exposed and effective portions of the endless roller trains are seen. Part of the foundation blocking employed for supporting the vertical girder appears in the lower foreground.

In reassembling the gate leaves in the field, the roller and wedge assemblies shown in Fig. 5 were "upended" and bolted to the previously aligned roller tracks. Laminated shims were inserted between the outward facing flanges of their transverse I-beam spreaders and the closely adjacent roller-track surfaces until metal-to-metal contact was secured. The bolts passing through the flanges of these spreaders, the laminated shims, and the roller-track flanges were then drawn up tight. This insured uniform contact of the roller trains with their tracks and likewise insured that the ends of the cross

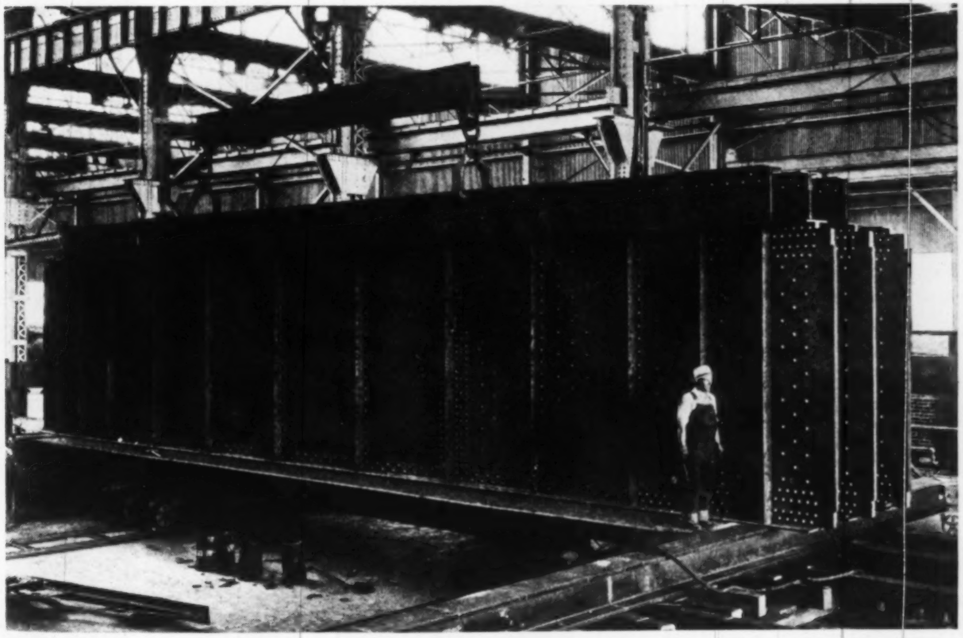

FIG. 19 FIRST THREE CROSS GIRDERS SET ON LEVELING BEAMS

(Each girder weighs more than 64,000 lb. Compare size with man at right.)

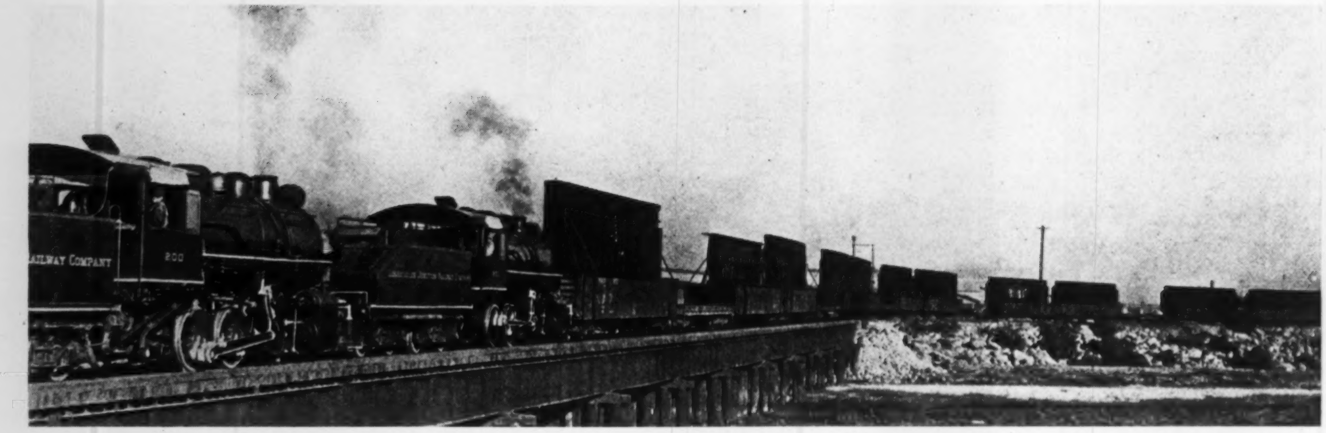

FIG. 20 "DOUBLE-HEADER" PULLING "TRIPLE LOADS" COMPRISING PART OF THE GIRDERS REQUIRED FOR ONE GATE

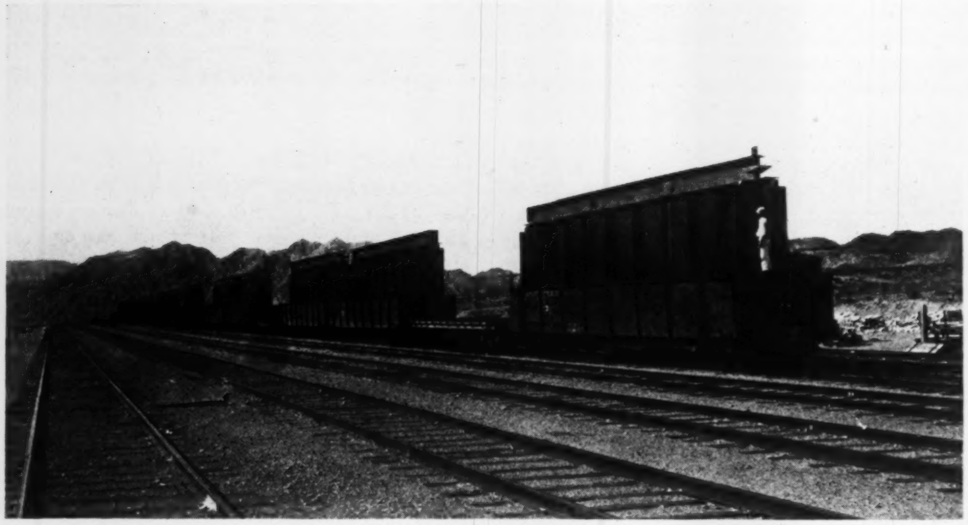

FIG. 21 HALF OF THE GIRDERS FOR ONE GATE IN THE FREIGHT YARDS AT BOULDER CITY

(The background of bare, rugged, rocky hills is typical of the locality.)

girders, as they were consecutively swung into place and bolted against the upstream faces of the babbitt plates, now a part of these roller and wedge assemblies, would receive full bearing support and so would transmit their loadings into the roller trains in a proper manner. This feature, in conjunction with the fact that the bottom cross girder in each case was supported throughout its length by the finished face of the seat bar on its under side resting upon the upturned finished face of the previously leveled and aligned erection support (20) seen in section *A-A* of Fig. 17, insured that the members would correctly match in properly leveled and plumbed positions as they were placed, and made the field work simple and easy to do.

The bolting of the vertical girders was held back sufficiently so as to allow the easy entering of the cross girders, as these were being assembled two or three panels above.

All bolts and rivets other than those specially noted are 1 in. Twenty-two thousand field rivets were driven in each leaf for the skin-plate units alone.

A local Los Angeles consulting engineer employed by the Government as inspector on these gates wrote: "The shop assembly of these gate leaves is really quite spectacular. Each of these leaves contains more structural steel than that employed in most of the height-limit office buildings in Los Angeles."

In Fig. 20 part of the girders required for one gate may be seen in the "double header" pulling out of the freight yards at Los Angeles, while in Fig. 21 half the girders for one gate are shown after their arrival in the switching yards at Boulder City with the bare, rocky, sun-scorched mountain tops forming a background typical of the area within which Boulder dam is located.

Each of these gate leaves, complete with wedges, roller trains, etc., weighs approximately 2,123,000 lb, while each gate frame weighs an additional 515,000 lb.

In Fig. 22 are shown the assemblies of the top and side seals employed upon these gates and the associated parts and mountings. The main seal members consist of rectangular bronze bars carefully machined and fitted in machined steel castings extending across the top and down each side of the gate leaves. The side or vertical seals of each gate rest upon the finished surfaces of the roller tracks throughout the entire travel of the gates, while the upper seals across the tops of each gate are in contact with the exposed, vertical, finished flange face of an I-beam embedded in the concrete across the

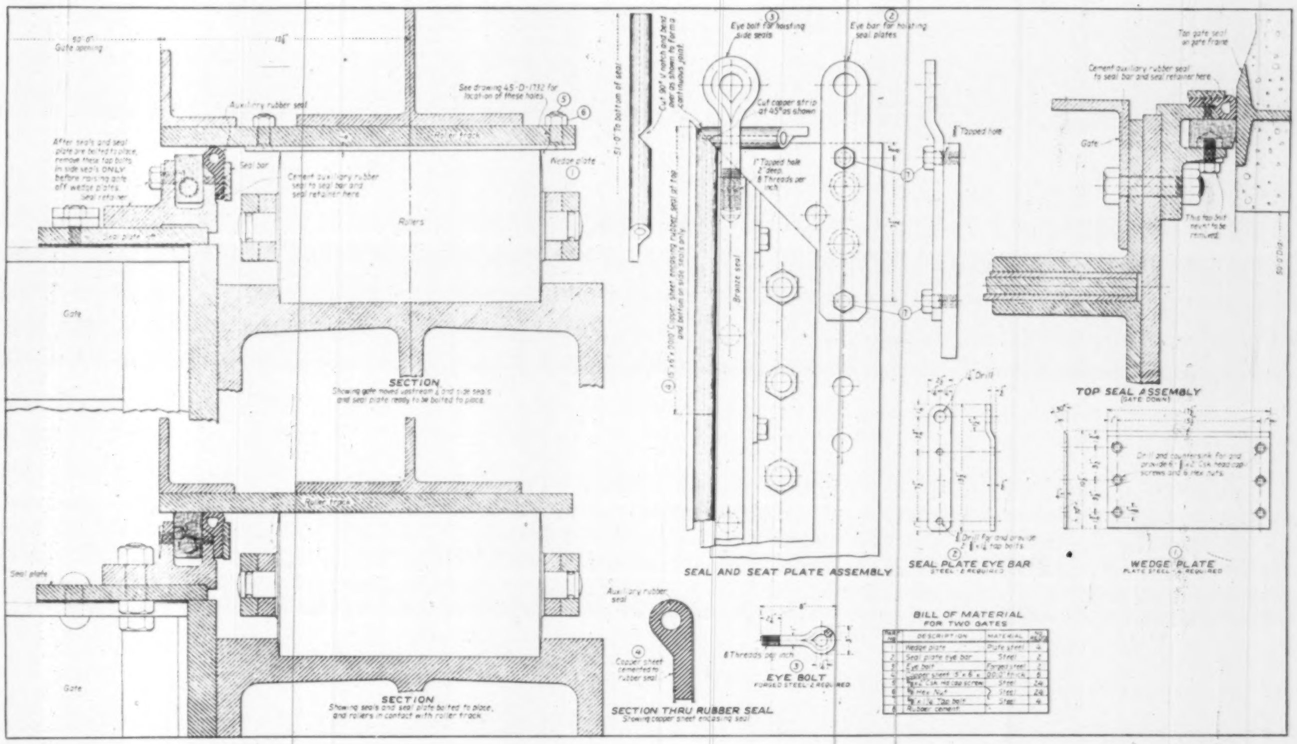
Auxiliary rubber seal
Seal bar
Cement auxiliary rubber seal to seal bar and seal retainer here
Wedge plate
Rollers
Gate
Roller track
SECTION
Showing gate moved upstream 1 and side seals and seal plate ready to be bolted to place.
Seal plate
SECTION
Showing seals and seal plate bolted to place, and rollers in contact with roller track.
Bronze seal
Eye bolt for hoisting side seals
Eye bar for hoisting seal plates
Cut copper strip at 45° as shown
Tapped hole
SEAL AND SEAT PLATE ASSEMBLY
Auxiliary rubber seal
Copper sheet cemented to rubber seal
SECTION THRU RUBBER SEAL
Showing copper sheet encasing seal
EYE BOLT
FORGED STEEL 2 REQUIRED
Drill for and provide 2 x 1¼ tap bolts
SEAL PLATE EYE BAR
STEEL 2 REQUIRED
Top gate seal in gate frame
Cement auxiliary rubber seal to seal bar and seal retainer here
Gate
TOP SEAL ASSEMBLY
(GATE DOWN)
WEDGE PLATE
BILL OF MATERIAL
FOR TWO GATES
DESCRIPTION
MATERIAL
Wedge plate
Plate steel
Seal plate eye bar
Steel
Eye bolt
Forged steel
Copper sheet
Csk. Hd. cap screw
Hex. Nut
Tap bolt
Rubber cement

FIG. 22 BULKHEAD-GATE SEALS WITH FIELD ASSEMBLING EQUIPMENT

top of the tunnel portal in the manner shown in the assembly in the upper right-hand corner of Fig. 22, as the gate reaches the downward limits of its travel. In this figure the dual-type side- and top-seal assemblies show the relationship of the sealing equipment with respect to the roller trains and tracks and the associated structural flanges of the gate leaf, also the special equipment employed for assembling these seals on the gate leaves.

The seals and the seal members are mitered at their upper joining corners, as shown in the seal and seal-plate assembly in Fig. 22.

Powerful coil springs spaced on 10-in. centers are inserted into $1^1/_8$-in. holes drilled into the 2-in. by $2^1/_2$-in. bronze seal bars to force them into engagement with their sealing surfaces.

Supplemental "music-note" type rubber seals are clamped to the exterior faces of the steel castings containing the bronze seal bars in the manner shown in the various assemblies in Fig. 22. A cross-sectional detail of this rubber seal is shown in the lower central portion of this figure. This special type of rubber seal was developed by the Reclamation Bureau several years ago and has been used successfully on many radial gates and similar installations.

The bottom seal employed with these gates consists of a $11^1/_4$-in. by 1-in. plate placed vertically and backed by a 11-in. by 2-in. plate riveted through to enclosing 8-in. by 6-in. by $^3/_4$-in. angles whose horizontal legs are riveted to the under face of the bottom cross-girder web plate to align with the skin-plate units above, in the general manner shown in section *C-C* of Fig. 12.

The lower finished edges of these bottom seal plates, which extend between the vertical girders of the gate, are embedded in hard babbitt contained within channel members cast into the concrete of the portal floors. The relationship of these babbitted seal members with respect to the gate-frame parts may be seen in Fig. 17 in the sectional plan at centerline of tunnel, in upstream and side elevations, and in section *B-B*.

Heavy structural-steel guide shoes are provided on each side of the gate leaves, near the upper and lower ends of the vertical girders as may be seen in the upstream and end elevations of Fig. 12. These guide shoes are made long enough to bridge the ends of three cross girders so as to avoid localizing the heavy lateral loadings that may fall upon them during final closure. It was originally intended to use appropriate forms of guide wheels for this purpose but it was found that the side thrusts which they would have to withstand were of so high values as to make their use for this purpose impracticable.

The concluding article of this series will describe the erection of these bulkhead gates and their hoisting mechanisms.

FINDING WORK

A Standard Technique Applied to the Needs of Engineers

By SAMUEL S. BOARD[1]

At the Semi-Annual Meeting, Denver, Colo., June, 1934, of The American Society of Mechanical Engineers, a resolution, relating among other things to unemployment among engineers, was presented by the Conference of Local Sections' Delegates to the Council of the Society. The resolution was referred by the Council to its Committee on the Capital-Goods Industries. Last month, under the title, "Durable Goods and Engineering Employment," the report of that committee was published in MECHANICAL ENGINEERING. In presenting the report to the Council, the committee recommended that a pamphlet be prepared that would deal in a practical way with the important problem of finding work. Mr. Samuel S. Board, placement specialist, of New York, was engaged to prepare this pamphlet. The accompanying article is the text of that pamphlet. It is to be reprinted from MECHANICAL ENGINEERING in a pamphlet of convenient size and will be available in single copies in lots of any number desired for a nominal charge. Copies may be ordered from the Publication Sales Department, A.S.M.E., 29 West 39th Street, New York, N. Y.

THERE are very few men out of work today who have not made the rounds of companies with which they are familiar, of friends, and of organizations which list jobs; many of them have tried the methods which other men have used successfully; and yet they have not been placed or they have taken wholly inadequate positions. There is no patent method which will reach the needs of all of these men. The techniques of finding work have been tried repeatedly, and while there may be variations, in the end the same procedure must be adopted.

No claim is made for originality in connection with the suggestions which follow. They involve merely a restatement of the *whole* process which must be followed in finding work when it isn't easily available. By a careful check as to what you or any one else has done in attempting to secure work, you may find *some* point which you have overlooked or some little thing which is wrong and which is enough to make the difference between success and failure.

Some years ago a really able sales manager lost his job because of difficulties in the company for which he had worked and finally came to me to check over his procedure in securing a new one. He had tried for several jobs and had been turned down in favor of some one else each time. He realized that something must be wrong but had not been able to determine just what. A careful review of what he had done each time revealed the fact that he had passed the first interview with flying colors but had fallen down on the second. When asked how long this second interview usually lasted he replied that he stayed as long as the prospective employer seemed to want him to—two hours, three hours, or even longer. This seemed to be the difficulty (why, will be explained later), and after he had shortened this interview to twenty minutes or slightly more, he secured the next job for which he applied. This may seem to be a small matter, but it is little things which frequently cause the difficulty. The following article, therefore, is presented so you may check *your* procedure against what might almost be called "standard practise." If you are going to read it at all, I should like to ask you to read it through, even though some of it may seem irrelevant to your particular situation.

DISTINGUISHING FACTORS IN THE ENGINEER'S PROBLEM

Despite the fact that most elements in the situation facing the engineer seeking work are similar to those facing other men, there are some which differentiate him from other groups of the unemployed. All of these elements will be found separately confronting some other group, but it is the combination which is certainly distinctive.

One of the most important of these is the fact that the engineer is so often employed by the job. Of course, laborers and artizans and sometimes such semi-professional workers as accountants are employed in this fashion, but on the whole men of comparable grade and ability such as major and minor production executives, salesmen, credit men, purchasing agents, and so forth, work not by the job but for an indefinite period until business contracts, the organization changes, or they fail to grow with sufficient rapidity to keep up with the requirements of the work. This means that whereas the other professional or semi-professional men may give their attention in the main, to "making good" on the job, the engineer must usually keep his eyes open for the next job. During such a period as that between 1923 and 1929, this may be largely unnecessary, since the demand for men of real ability is greater than the supply, but even under such circumstances the engineer, especially the young engineer, may be out of work for a period of from two weeks to three months. Such a lapse is a tremendous economic loss when the total time is figured.

This problem is, of course, intensified during depressions. While many other types of workers are "carried" by their firms even when work is slack, the engineer is likely to be laid off as soon as the need for his services has passed, especially if he has been with the firm a comparatively short time. There is, on this account, an especial reason for his attempting to work out an orderly method of advancement and for his learning the technique of selling his services when a change is necessary.

For some reason—perhaps because they are more used to studying materials and processes than people—many engineers seem to have little understanding of the fact that there *is* such a technique. Even sales engineers fail to study this question from a sales standpoint. The importance of making it a study, however, cannot be overemphasized.

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[1] Placement Specialist, New York, N. Y.

Back in '28, the president of a good-sized Chicago company telegraphed my office that he would be in New York the following day and wanted to see three sales engineers out of which he would pick one. Three good men were corralled for him and were duly interviewed. Afterward, the one I myself had rated as best in experience and ability came in and said that he had the job. (Those were the days when employers did not feel that they had to negotiate for six weeks or six months before employing men.) Long experience had made me skeptical regarding the validity of any hiring on the basis of a three-quarter-hour interview so I asked the engineer how he got the job. He laughed and said, "Well, I discovered in the first two minutes that he was an enthusiast about small boats. I've handled and sailed them all my life, so we talked forty minutes about boats and three minutes about the job, and I was hired."

Even though you may not think this employer was careful enough, the man *did* understand the principles of selling and applied them successfully. Many engineers either do not understand them or fail to use them when their own future is the subject of discussion.

A third distinguishing factor in the engineer's situation is connected with the cyclical variations of business activity. Frequent reference is made to the "business cycle" as if the variations were the same for all industries, when as a matter of fact the curve which is referred to is a composite of many curves which vary in periodicity and intensity A great many engineers are employed in connection with the heavy industries and the building trades. While some of these, at least, have longer cycles, the intensity of the swing is greater and therefore the unemployment is more severe. Many engineers also are employed in the developmental side of business and such work is more likely to take place during business rises or when money is easily available. In mentioning this there is no intention of suggesting that engineers should not engage in such work but merely that these conditions should be reckoned with and an effort made to discount them.

This can be done in several ways. It is possible to specialize as to one's major occupation and yet maintain sufficient contact with other types of work so as to shift when the times demand it. Hobbies which may be entirely outside the technical fields have provided depression occupations for engineers. At least two engineers of my acquaintance assured me that they made quite satisfactory incomes during the picture-puzzle craze by cutting them out for the high-class shops on the jig saws that were a part of their home workshops.

A sounder method, however, would be, I believe, for men who have worked for the larger companies and on larger projects to search out smaller manufacturers when times get slow and give them the benefit of engineering knowledge, since small plants, if efficiently managed, can adapt themselves more easily to changed conditions than can the larger ones and can hire experts when they are available, without upsetting a general policy.

One Connecticut manufacturer told me that he saved 60 per cent of his fuel bill one year during the depression by putting two young mechanical engineers on a job ordinarily done by laborers and then getting them to show the others how to do it properly. This sounds almost fantastic, but his plant made money that year when other similar ones did not. Of course, the biggest difficulty in undertaking to make a job like this, when one is not obvious, is that of "selling" these small employers. Many of them are not so intelligent or progressive as the one mentioned, but it can be done.

The differences just reviewed between the problem of the unemployed engineer and that of another educated man are not really so large, but they should be considered in devising any real attack on the unemployment problem of the engineering group. Even though this is so the attack must be along the same general lines as should be followed by any man out of work. Essentially, the problem for the individual is the problem of salesmanship. He must first determine the value and uses of what he has to offer. Then he must find a market, and, finally, he must outline an advertising and selling campaign which will inform possible buyers of the value of his wares in such a fashion as to make them pay real money for them. This is a simplification of the procedure which will be outlined in the remainder of this discussion.

WHAT THE ENGINEER HAS TO OFFER

As has been stated, the first step which must be taken in selling a man's services as in selling a product is to determine what he has to offer. Something of an analogy is offered in the development and marketing of cellophane. According to the information at my disposal this was one of a number of products developed by the du Pont laboratories to use up the nitrocellulose left after the War. The Government took most of its share out to sea and dumped it after caching a certain amount for future emergencies; but the du Pont company, being a private concern, did not feel it could do this and set its technicians at work to find other uses for it. Cellophane was one of the results. Even after it was ready for production the laboratories and the sales force had to study its uses, alter its composition to meet new requirements, and determine its tensile strength and ability to resist moisture. If they had not done a thorough job on that phase of the marketing, the phenomenal increase in its use could not possibly have taken place. Now they even make women's dresses of it.

Let us pursue somewhat the same method in determining what the engineer has to offer. In the first place, nearly every trained man has two antithetical advantages in amounts which are in inverse ratio to each other. Either he has youth and is relatively inexperienced, or he is more mature and has more experience. I suppose there is a middle ground somewhere in the early thirties when he has both youth and experience in considerable measure but the exact point of balance is hard to determine and is not important. Young men do come to me though and complain that they cannot get work because they lack experience. Older men are discouraged because (they say) the world is looking for young men. Both are wrong. The young man can find certain work where experience is unimportant and the older men can find it where maturity and experience are assets. The mistake both make is in trying to reverse their positions.

In the main, I think it is safe to say that large corporations tend to look for younger men, while smaller companies or new businesses are likely to seek men of more maturity who can take responsibility rather quickly. However, if you are young, you can sell the idea of youth and enthusiasm and the desire to work under some one who knows what it is all about.

If you are older, you can emphasize the value of your experience, the importance of your past positions, and the maturity and seasoned knowledge which you can bring to the job.

If you must seek work outside your own field it will mean, of course, that you must break down your experience into functions performed, in order to discover those easily adaptable to other types of work. For example, a mechanical engineer may be thought of to the world outside of the engineering fraternity in terms of the construction and operation of machines and power plants, whereas, you know that a mechanical engineer may be a designer, an operating superintendent, a test engineer, a sales engineer, a manufacturing executive, a production engineer, a research worker, and a lot of other things that I may not know. Moreover, there are designers of turbines, of automatic machinery, of fine tools, of automobile and airplane engines, and an almost infinite variety of machines and products. All these different types of work involve variations in interest and ability which can be used in describing your abilities along other lines. I do not mean to infer, of course, that what you have done in the past limits what you may do in the future, but the experience and abilities you know you possess may at least be used as a means of transition and should be so used.

Many men who are forced to seek work outside their immediate field try to make, as they say, a clean break and secure something which is entirely unrelated to what they have done before. Even though this may be a natural reaction it is an expensive method, since it usually means taking a beginner's wage. However, if you are willing to take a job in which some of your former experience can be used you can obtain substantially more and then later on take another step farther away and continue that process until a satisfactory occupation is reached.

In any event the only common denominators between jobs are the activities which are involved in these jobs. Any man who can do fine work with tools in one line can probably do similar work with different tools in another line. A person who is used to assembling and interpreting data can, at least with some training, take up this activity in another field. A man who is used to handling workers in one type of factory will not have much trouble learning to handle people elsewhere. Have you thrived best where action was involved? Seek action in a new job. Some day a dictionary of work functions will be prepared and then the task will be simpler. Meanwhile we must interpret our own past activities in terms of new jobs, just as we would describe what a product would do.

IMPORTANCE OF APPEARANCE

The next most important phase of the study we are making is that having to do with what compares to the appearance, fiber, form, and shape of a product. In other words we must be prepared to describe the physical and mental equipment, the appearance, and the personality of the man in question. It is much more difficult for a man to do this for himself than for him to describe and study his experience or his specific work aptitudes. Yet it must be done since no job specification is written without including some of these factors, and to determine whether we meet these qualifications we must have some idea as to just what specifications we can meet.

It is also important as a preparation for the interview by which we may attempt to sell our services. In any such interview, a good share of the impression we make will be governed by what is termed our personality. This includes general appearance, clothes, voice, language, timidity or aggressiveness, and responsiveness to ideas. Of course, there are some things in this category that we just cannot change and these are the points on which men are prone to dwell in their own thinking. After we are twenty, for instance, we can't add to or detract from our height, and most of us haven't come to the point, even if some bandits and the ladies have, of employing plastic surgeons to alter our faces. We can, however, even with limited means, be sure that our clothes are suitable and in order, that we look well-groomed, that our expression is alive, our faces mobile, our voices resonant, and our bearing alert.

Some engineers seem to feel that paying attention to personal appearance smacks of the beauty parlor, but that is all tommyrot. Being sure your appearance is suitable is what counts. It wouldn't be safe to go out on many engineering jobs wearing spats and carrying a cane, but these accoutrements are an advantage on some jobs. Neither is it suitable to apply for an office job looking like a tramp or to ask for work on a relief project looking like a million dollars. One of the most pathetic stories of the depression has to do with an instance of this. It seems that an elderly clerk, who had worked for years in the financial district only to be laid off in the early part of the depression, was literally destitute. He and his wife were starving when some one told him about a relief job that he might get the next morning. By this time his clothes were rather shabby but his wife sat up all that night sponging and pressing his only decent suit so that he would be presentable. She did too good a job, however, because when he applied for the relief job he looked so prosperous that they would not believe he needed help and refused to do anything for him.

You really must dress and act the part in applying for any job, and the first step in doing this is to appraise your usual appearance, your personal assets and liabilities. It is comparatively easy to compensate for or remove liabilities and it gives you so much more confidence if you are aware of your assets.

MAKING A PERSONAL APPRAISAL

There is one great danger in this matter of personal appraisal and that is the possibility of its degeneration into introspection. This will be very likely to happen if you try to assemble all these facts you have been gathering in your head. It just cannot be done properly that way. While you are considering one set of facts, another will be disregarded, and vice versa. The only safe way is to organize it carefully on paper. In order to make this easier an account is given of just how this recording may be done.

Let us start with your experience. I should prefer to start with the personal qualifications just mentioned, but it is a little easier, apparently, for most men to start the other way. In listing your experience take it in the reverse order, starting with what you have just been doing and working backward. Put down what you did, the firm's name, the length of your stay, and the range of salary you received. Then break down the jobs and list the various activities involved—whether you hired men, laid out work, figured costs, did a certain kind of designing, or what not. If your experience has been diverse enough, you may find it desirable to rearrange these bits of experience and find out just how much time you have spent in each activity.

If you are younger or had an interesting and varied school experience, it may pay you also to go back and analyze that in the same way. Perhaps there were abilities uncovered then which you have not used since. The same procedure should be followed for your avocational and family interests. Try and remember your activities along all these lines in 1933, 1932, 1927, and 1925, for instance. Throughout this whole analysis a keen watch should be kept for trends in experience and avenues of growth. The possibility of finding these is one reason for arranging the data in chronological order.

Next, your personal characteristics should be described in as objective a way as possible, depending more upon what other people say about you than upon your own estimate. Of course, your mental assets can be gaged in some measure by your scholastic record and the recognition you have received since. It isn't wise to ignore your important liabilities, but emphasis should be kept on the positive side.

You should then have a pretty good picture of yourself and what you can do best. The next thing is to decide what types of work you would like in the future and under what conditions. There may not be much difference between some of them, but it makes it easier to grade them as to desirability, when possible, and put it all down on paper.

Of course, none of these may be possible immediately and they may not even exist as jobs. Men have come in to me and spent several minutes describing the sort of work that they desired and then I have had to tell them in the end that the job just did not exist as far as I knew. They have simply made a synthetic job out of their desires. You will be able to determine this for yourself if you will leave the personal question for a while and consider what functional types of work are open. Since we are concerned at the moment with engineers, I shall try to discuss the markets for the services of engineers even though this must be done in general terms.

TYPES OF WORK OPEN TO ENGINEERS

It is easy to talk about engineers as if they were a peculiar race of men, set apart somehow and separate from the undistinguished rest of mankind, but I refuse to treat them that way. To me they are much like other men. They have the same domestic problems, the same desire for power and for money, the same urge to serve their fellowmen that others have. They may have these in degrees which vary from the degrees which others have them but in general they are just people, despite their scientific training and the wizardry which they sometimes seem to others to possess. So, also, the work that they do does not vary greatly from the tasks that occupy other people. In fact, they enter all sorts of occupations and professions. I know men trained as engineers who are accountants, lawyers, salesmen, artists, politicians, and, I think I might add, ministers. Some of them have discarded engineering as a profession but many have merely combined it with other activities. Nevertheless, there are certain types of work in which engineers are ordinarily found, and, if we are to discuss at all adequately the opportunities for engineers seeking work, it seems the obvious thing to do to cover this better known ground first. I propose to do this on a functional basis instead of using the usual method of dividing the varieties of work according to the engineering degrees of the men who most commonly undertake these tasks.

GETTING THINGS DONE

Suppose we consider the engineer first as an operating man. He gets things done. Usually he will be found in command of at least a small group of men. Perhaps his greatest satisfaction comes from seeing the results of his labors—so many cars turned out each week, or so many barrels of gasoline, or a bridge farther along toward completion, a building built, a railroad kept running, or a communication system kept in operation. His is the brain that checks on the labor of others, that corrects mistakes and surmounts difficulties, that tells how and where and with what tools a task is to be done. In this group come primarily the civil engineers, the construction men, and the mechanical and electrical engineers—all of them types of engineers who have found it especially difficult to get jobs in the fields in which they customarily work during these hard years. We have not, except as the Government has been pouring out funds, been building very much. Many of these men are in the so-called capital-goods industries, in which the index of employment is still abnormally low.

If you are in this field of activity or have been and your genius is getting things done and in producing tangible goods, why not turn to the other operating fields and see if there are not more opportunities? Plants need to be run as well as constructed and in times past many men who have designed plants and built them have stayed to operate them. Moreover, with more stabilized prices and increased mechanization the operation of plants and factories should and will demand more technical skill on the part of those in authority.

Most engineers understand machines and are fascinated by them. There is no reason why they should not extend their field of usefulness into a great many industries in which the "rule of thumb" is still the governing principle. It is foolish for an engineer, if he is competent, to think that he needs to have experience in any particular industry to do the work necessary in that industry. A few years ago a manufacturer of a rather complicated machine, wanted a factory superintendent. It was specified, however, that any one applying for the position must have had casehardening experience, since that was an important part of the manufacturing process. A competent engineer of my acquaintance felt that he could handle the job even though he had not had such experience. Before applying for the position, however, he spent three days in the New York Public Library reading up on all the latest developments in casehardening. He found out so much about the problems involved that he secured the position in spite of competition with experienced men and even though he frankly confessed his lack of actual experience in the field. He did a good job, too. We are sometimes afraid of the bug-a-boo of specific experience. We ought instead to realize that a man with a trained mind who is not afraid to tackle new problems and is not too diffident about seeking information can bring a valuable and often fresh point of view to the solution of problems that have not been properly solved, because they are too greatly bound around with traditions of what has been done in the past.

There is one phase of an operating job, however, which bothers a good many engineers and to which they need to give close attention. That is the human factor. It simply isn't possible to treat men and women as you do machines. Allowance must be made for individual differences, for prejudices, for ambitions, and for fixed ideas. A certain amount of inspiration as well as consideration, must come from the man responsible for supervision. Scientific management, which is, I take it, principally the application of engineering principles to human productive activity, must sometimes go slowly and allow for the absorption of ideas, in order to save time and money in the end. The engineer's impatience with human frailties seems to be the greatest limiting factor to his usefulness as an operating man.

There is another factor in operating, however, which favors the engineer. Even though the introduction of machinery has reduced the number of workers in many industries, it has increased the need for maintenance engineers who must see that these machines run, are operated properly, and are kept in good condition. Just after I had finished a period of employment as a machine operator, a well-known psychologist told me that it would not be very long before all machines would be automatic and would be run by morons, meaning, of course, people with less than average intelligence. I was highly indignant at the time because I had come to realize by actual experience that, whereas the manual labor necessary is undoubtedly reduced by automatic machinery and the time necessary to learn the procedure may be cut down to a negligible period, understanding the operation of the machines and being able to act correctly in an emergency requires a high order of intelligence, at least of a certain kind. It also involves a thoroughly trained person to correct difficulties when they occur. Moreover, modern production processes are so closely interrelated that the overproduction of one part or the breakdown of one machine may upset the schedule of a whole factory or series of factories. Here, in the more accurate coordination of production, lies a large opportunity for the trained mind of the engineer. It may be necessary to sell this idea more thoroughly to manufacturers and perhaps you as an unemployed engineer can have a very definite part in so doing. It certainly can be done.

RESEARCH

We must proceed to discuss some of the other phases of work commonly done by engineers and perhaps the next one which should be mentioned is that of research. Business men have come more and more to appreciate the practical results of research even when it seems most remote from the work in hand and scholars engaged in research are coming to appreciate the fact that the pursuit of new knowledge may be profitable financially as well as intellectually. Surely, much progress has been made in a better understanding of the possibilities of research when one of the foremost leaders of industrial research announces that a part of his staff has been engaged for some time in trying to solve the riddle of why grass is green! This, in spite of the fact that there is no apparent connection between this field of research and the products produced by his organization.

Research today, as most of us know it, takes on a multitude of forms. It may involve the experimental design of new machinery, extensive microphotography, the careful analysis of new and old materials, the accumulation and sorting of information from a multitude of sources in order to determine which may provide a vital clue to an entirely new procedure. Many men haven't the patience for such work, they can't stand the inaction, or, most of all, they haven't the controlled imagination.

It is a mistake, however, to think that all such work is done in the universities or in the big corporation laboratories. Much valuable research has been done in lofts, in small shops, or in private laboratories. To discover these smaller enterprises requires something of the instincts of a ferret. They must be searched out, followed up patiently, and approached with caution. Much of this work is not profitable from a monetary standpoint or from the point of view of results, but if you have that type of mind and will apply the same techniques to the discovery of opportunities to be associated with such ventures as you would use in other research, they can be found and are probably not much more hazardous financially than a host of other occupations. Such work is entitled to be called professional from almost any aspect.

THE CONSULTING ENGINEER

Of all the work that an engineer does, however, that of the consulting engineer is probably nearest to a completely professional status. Also, it involves some of the most varied abilities. The good consulting engineer must have the analytical ability of the research man, the operating skill and ability to handle people of the operating man, and the enthusiasm and the financial acumen of a good banker or controller. He must keep in touch with new ideas and yet have a comprehensive knowledge of what has gone before. Above all else he must have the ability to plan the expenditure of his own time. Does this sound like a large order? Well, it is.

Perhaps the good consulting engineer comes nearer to being a master of his field than any one else. Excellent engineers who can do splendid work as employees find themselves unwilling or unable to assume the responsibility of independent action. Others lack the ability to sell their services to prospective clients. It is likely to be either a feast or a famine. Either a consulting engineer is so busy that he cannot handle the work and finds it difficult to hire other men who will do it efficiently, or he has time on his hands and has to employ all the arts of a salesman to get enough business to provide him a living. Some engineers find the answer in supplementary occupations, such as teaching, the management of organizations, or through a regular consulting arrangement on recurring problems. The best consulting engineers I have known have been men who have worked for others on a variety of problems, frequently in various parts of the world, and then, after they have had the benefit of this experience, have settled down in some central location to make their experience available to whoever have problems to solve. They are men with standing and prestige who are recognized as authorities. Business in good times naturally flows to them. In poor times they live on their accumulated savings or go into other lines of work. Sometimes they tighten their belts.

It would be possible, and perhaps profitable at another time, to analyze the requirements of a consulting engineer's work more fully, but at the present (the fall 1934), when we are partly through a depression, is not a time when it is possible for very many to enter this field, and there are other possibilities for engineers which should be given more attention.

SALES ENGINEERING

One of the principal fields of work for engineers outside of what may be called straight engineering is that of sales or sales engineering. Many engineers have tried to go into non-technical selling without much success, but increasingly, products of a technical nature are demanding engineers to sell them, even some which may be classed as "consumer goods." There are large numbers of machines and basic materials—metals, chemicals, rubber, fabrics—which are used in manufacturing and which must be sold by men who can appreciate their uses and help adapt them to various mechanical situations.

Many men, especially engineers, say and feel that they cannot sell. Some, of course, cannot, but the main reason why the others feel that they cannot is because they think of selling as peddling, or as forcing on buyers things which they do not want and cannot use. True selling is almost the reverse and consists of so appreciating the problems, needs, and personality of the buyer as to be able to make him see, understand, and want the product being offered to him. If it is not desirable and useful in a given situation it should not be sold.

Let us analyze this statement a little further. In the first place, a salesman must study and understand the problems of the buyer. This involves learning as much about his needs as is possible ahead of time; then gathering by skilful questioning of the purchaser more information, including his own prejudices in the matter. Second, it is necessary to understand the buyer himself, to apprehend—there isn't any other word for it—his thoughts and thought processes. Third, the salesman must "get his ideas across" to the buyer convincingly and persuade him to make a decision; get him to "sign on the dotted line." This does not involve "high pressure" selling necessarily. It merely means creating a sufficient desire and then letting the buyer take the initiative. If the salesman is interested sufficiently in people and is sufficiently interesting to them to get their goodwill, the rest of the selling technique can be learned.

Many men think that it makes no difference what they select to sell, but my experience indicates that it makes a lot of difference to the beginner, at least, since, to sell convincingly, most beginners must understand, like, and believe in the product. There is a big field for engineers here, however. As competition becomes keener in this country and prices become better standardized, the art of selling will be more and more necessary, and those understanding it will be in greater demand. Pick your line, pick your company, and you can frequently sell them the idea of taking you on.

One more point regarding sales work should be discussed briefly; that is, the methods of paying salesmen. At the risk of being seriously challenged, I should like to say that most worthwhile selling jobs today pay a salary or a salary and a commission. If a sales job does not do so, the employer is asking the salesman to take most of the risk. A drawing account is something of a compromise. The salesman is paid a commission but is allowed to "draw" a fixed sum every week or month which is deducted from the commissions he earns. If after a certain period he has drawn more than he has earned in commissions, he is supposed to make up the difference. The company does not always demand this if it is felt that the drop in earnings is not the salesman's fault, but it is considered an obligation and therefore should be set at the start at an amount which is a little less than the expected earnings from commissions.

Many types of goods and services are sold on a commission basis and some men prefer this basis because of the larger percentage given, but it is a particularly harassing method of pay for a man who is methodical in nature. Most companies selling staple articles or articles which involve large unit costs, such as machinery, prefer to pay their salesmen salaries which net them a smaller percentage on their sales if they are successful, but, of course, do not involve so much uncertainty.

It has been pointed out that a salesman needs to be careful about his appearance. He does not need to be unpleasantly aggressive, but he must be well dressed and persistent enough to get a hearing. He must understand people sufficiently to make himself liked and easily understood—persistent but not a pest, in other words.

ENGINEERS IN BUSINESS

In addition to the foregoing functions of engineering which are generally recognized there are opportunities in other phases of business also. Many engineers, especially industrial engineers, eventually transfer to financial positions, such as controllerships. Others secure places for themselves as technical advisers to banks and accounting firms. These positions are likely to be a step beyond consulting work instead of a prelude to it. Others, who are interested in people and their efficiency, go into the personnel field. Many purchasing agents are engineers. Lately, a number of mechanical engineers have entered the planning departments of retail stores in which the handling of goods from the receiving office to the customer is, in many cases, an engineering problem. There are also places for engineers in the editing of technical magazines and books, and many go into various phases of the civil service.

It would be impossible within the limits of this article to give detailed analyses from a functional standpoint of all these various business and public occupations into which some engineers go, and which do offer a wide variety of opportunity if properly investigated. There are numerous books describing them and if these are carefully studied the information can be obtained from them. There are certain of these occupations about which I shall attempt to comment briefly, however, because the information may not be obtainable elsewhere. One of these is banking.

After a good many years' study I am convinced that the only way for an engineer to become connected with a bank in the capacity of advisor on industrial problems is either to become acquainted socially with one of the bank officers, or, more properly, and I think more easily, for him to meet the bank officials in the discussion of a problem in which the bank is interested. Bankers who are impressed by an engineer's handling of an analysis or by his solution of an operating problem will, at times, seek his help with other problems, and, in order to avoid paying a heavy consulting fee, will take him on at a substantial salary. To be able to create this opportunity for himself a man must have a flair for finance because he must be able to talk the language of the banker and because the financial aspect of the problem is likely to play a considerable part in the work he is asked to do.

Purchasing is a distinct career which is usually entered early in life. There are, however, instances in which engineers have been able to secure such opportunities later. This is especially true when they have been engaged in industrial reorganization. In order to purchase successfully, a man must have an almost unlimited capacity for absorbing detail without being swamped by it, must be interested in and understand markets, must be able to understand but not necessarily to like people, although that is a help. His judgment and ability to decide promptly must be excellent and he must be able to make decisions without worrying about them. A purchasing agent can many times put a firm "in the black" or "in the red" simply by buying at the right time and in the right quantity.

Planning departments are likely to assume the aspect of boards of strategy. They have to do with the flow of goods and work in process, with plant layout, and, with questions of management policy. This field is a good example of special jobs in which engineers are finding places.

Another job is that of building superintendent. In smaller buildings this may not be far removed from the work of a janitor, but in larger buildings the problem of mechanical upkeep makes an engineering training desirable, so that both mechanical and structural engineers will be found carrying on this work with success.

Nothing has been said so far regarding strange or unusual jobs which engineers have undertaken. There are many of them, but such possibilities are discovered either by chance or by an analysis of the individual's special interests. What has been attempted is a review, from somewhat of a functional standpoint, of the occupations usually open to engineers, in the hope that those who are unemployed may find something they have overlooked.

PLANNING A JOB CAMPAIGN

Perhaps engineers will be inclined to say—if they get this far—"Now at last we are getting down to something important." But if the preceding discussion has not been read carefully, what follows will probably be of much less use. You cannot plan a job campaign unless you know something about yourself and about the field of work you are approaching.

The first step in planning a sales campaign for yourself is the preparation of a statement of your record. A man came in the other day bearing a large folio-size volume, leather-covered, and two inches thick. It was filled with data about himself, his picture, letters of recommendation, even articles he had written, and yet to me it was almost a complete waste of effort since it was not assembled in an intelligent order. It had no index and there was no brief summary of the man's career or of what he could do. In any but the most exceptional cases, a one-page summary would have been far more effective.

Many plans have been outlined for preparing such statements and great things have been claimed for some of them, but rather than give an exact form, I am going to suggest certain principles. If you have made the personal analysis previously outlined, this is all that will be necessary. Be sure, however, to eliminate most of the details you have accumulated and make the result a summary.

In the first place, any such statement should contain a statement as to what you want to do, even if this has to be changed a dozen times in applying for a dozen different jobs. If you do not want to include this with the rest of the summary, it should be on an attached sheet or in an accompanying letter. How to determine this has been discussed previously. In the second place, it should contain a consecutive chronological experience record. There is no substitute for this. Recently, many men have tried to emphasize their abilities by describing functions they have performed without indicating how long ago they were performed and for how long a period. Such an analysis is of value and frequently helps the man, but it does not satisfy the employer unless, at the same time, he is given an idea as to when and how it was done. Also, I think it is helpful with most employers to have a picture of the flow of a man's exprience. Engineers who are hiring men seem to like this experience record presented in chronological order, but other employers prefer to know what the man's recent experience has been and give it more satisfactory attention when it is described in the reverse order. It is really better selling to present it this way also, since, otherwise, the reader is likely to give too much attention to the time the applicant was an apprentice or an office boy.

Finally, such a record should be rounded out by giving details which will complete the picture of the applicant as a man —his birth, education, family status, interests, and habits.

Of course, the physical make-up of the summary must be varied to suit conditions, depending on whether it is to be used in a letter or presented in person, but it is desirable in any case to have it written out. It is easier to present verbally, it reinforces the applicant's case afterward, and it seems to act as a reminder.

If it is to be used for such a purpose it should be typed or printed with a pen, well laid out on good paper, and as concise as possible. Many times such a record can be condensed to one sheet of paper. At the most it should not be more than two pages long.

There was a time when booklets or brochures were uncommon enough so that employers would read them through, but, unless they are brief and extraordinarily well done, employers now are likely to look at the first page rather carefully, glance at the second, and thumb the rest. It does no good to write a nice story if it is not read.

Perhaps a word should be said about references. The general reference is so much abused in this country that it is of little use except to verify dates and duties. Employers wish rather to have the privilege of consulting the people themselves for whom the applicant has worked. Occasionally, a letter written by a former employer to some other person may be used, but even this is not given as much credence as a fresh inquiry. On this account such opportunities to refer to busy men should be used sparingly and only when a real job is in prospect. In many European countries, including Germany, the Scandinavian countries, and, I think, France, a man carries with him what amounts to a dossier—a complete record of his former employment with formal letters of reference—and such papers can usually be accepted at their face value, but the English follow a system much like our own.

WHERE TO LOOK FOR A JOB

After you have armed yourself with a summary of your experience and a decision as to what you wish to do, the next question is where you are to find a job. To do this (unless you quite literally create it) the surest way is to study the areas of opportunity. Given the abilities and interests you have, where can you find the opportunities to use them? You should have settled the question as to the functional part you want to pursue and know whether it is production, sales, or control, and then, within what type of business.

Suppose you are an operating man and wish to go into factory work. Shall it be steel or glass or textiles or shoes or machinery or automobiles? You must pick a field or fields—one, two, three, or more. The field should be located within the geographical area accessible to you and in which you want to work. It ought to have at least the possibility of being busy shortly. The business ought to be such an essential one that it cannot be discontinued and be in fair shape financially. Preferably it should not be popular or have glamour, like airplane manufacturing, else you will be elbowed by a horde seeking the same thing.

The next question is, do they use engineers? If they do not, could they? Perhaps you can sell them the idea.

There are more questions one could ask about the field, such as the limits of its rates of pay, the overcrowding of its ranks with technical men, and so on, but those already mentioned are fundamental. Where can you get this information? Any good newspaper, for one source; also from technical and financial magazines, from discussions with business men, and from the list of dividends paid or omitted.

Having selected three or four fields, the next step is to find in these fields specific companies whose policies are sound, whose product is well made, whose finances are not too involved, and whose affairs are not marked with an excess of internal friction. How can you find out these things? From the financial directories, from leaders in the field, from your bank, and from men who have formerly worked for the companies. All this information should be recorded, tabulated, and sorted, so that you can make a list of companies in order of the desirability of work with them, and then proceed to cover that list. Doing it in person is best—by letter, if there is no other way.

You must go after something *definite*, however. Don't just ask for a job. Tell your prospective employer that you wish to work for him and what you can do.

I'm talking, I know, to men, many of whom have been looking for weeks and months and even years—tired, discouraged, and disheartened—but, men, we must "sell them a bill of goods!" Many of you have just been asking for jobs. Others haven't been doing even that. They have been calling on acquaintances and wistfully asking them if they know of anything. What they forget is that they *have* something to sell—brains, experience, drive, enthusiasm, determination, even brawn, if necessary. We must not be apologetic or ashamed but *sure* that we have something to offer.

Several years ago I had a boss whom I still consider a typical example of the better type of business man and I learned quite a bit about selling ideas from him. I found that if I went down to see him in the afternoon and put an idea before him with pros and cons but without urging a favorable decision the answer was likely to be "no," but if I waited till the morning, took care to be well-groomed, entered alertly, explained the proposition, and said, "I think we ought to do thus and so," the answer was, "Go ahead." He wanted me to believe in it first. Lots of college men out of work have come to my office this summer. Some I have helped to get work, many are still looking, but there was one boy who stood out. He was a little under medium height, good looking in a way, but with no special attractiveness of that sort. However, when he came in he *knew* what he wanted to do. He presented his desires briefly but enthusiastically. He acted on suggestions promptly. The field he entered has been overcrowded and was dull at the time, but in two weeks he had three jobs lined up, and, naturally, he took one. It isn't so easy with older men, since there are fewer jobs and the requirements are likely to be more definite, but the approach makes a world of difference.

There are other ways of finding work. No one should be ashamed of using the help of friends, if it is offered, but you should help them by making clear what they can do to help. There are also employment agencies, public and private, good and bad. Despite the opinion of many, good opportunities are to be found that way. You should, of course, be listed with your professional society. There are the advertisements in the newspapers. These bring a lot of heartaches, however, unless you learn to discriminate between them and are willing to write repeatedly without having extended to you the courtesy of a reply. In reply to inquiries your letter should be as brief as possible. It should give the information asked. It should be carefully typed or printed (if you do hand-lettering easily and well) and set up so as to stand out for its neatness and clarity.

There are some good blind advertisements; but the chances are better of its being a genuine and desirable job if the firm's name and address are given. Blind advertisements are like blind dates—occasionally a "honey" but usually "sour."

Many men ask me about writing letters—letter campaigns—and about following up personal or letter applications. My experience has been that in good times letter campaigns are very useful. Frequently, we can get results from them (if the applicant is employed and wants a better job, for instance) through a third party, but in these times the only campaigns worth mentioning are those carried on in the name of the man himself to individuals instead of firms, and by means of individually typed letters *very* well done. Even these will sometimes bring a lot of nice replies without anything favorable. The writing of letters, however, by agencies and organizations has almost approached the stage of a racket, and in many places has spoiled this medium of getting jobs. As to follow up, you must strike a happy medium. It certainly doesn't do to let a favorable lead go too long unacted upon, but you must be careful not to arouse resentment by writing unnecessarily. Two-week intervals are about the right length in most cases, unless you are asked to do otherwise.

THE SALARY QUESTION

One of the most important matters to be decided in applying in person or by mail is the amount of the salary. If you can, and unless you know the rate the employer desires to pay, it is better to get him to make an offer which you can accept or try to raise as you think fit. If you *must* name a price, make it fit the job. It is no use asking too much for a minor job and it is foolish to ask too little for a good one. Even in these times I have known employers to turn men down because they were too eager for the job and have asked too little.

The first thing in determining a fair price is the value of the work to be done. If you can, find out what others are getting. Ask about standard prices in employment agencies; but find out if you can the *going* price for such work. Next, you should consider the policy of the company in question. Is it tight or liberal, prosperous or broke? It is foolish to ask as high wages of a company that is having rough going instead of having a nest egg in the bank. The third factor is the impression you make. If the price is not fixed, you can count on a difference of at least 30 per cent between the wage paid a man who is diffident or seedy or somewhat beaten and the man who is "on his toes" and confident of himself. Sometimes a man will have a big "front" with nothing behind it, but I don't know why a man who can do the work should not act as if he himself believed he could.

College men, as a whole, have been accused quite generally of thinking too well of themselves. After having worked with them for several years I should say the reverse is true, but engineers never could be accused of it. They may know the value of steel and brass and tools, but when it comes to themselves, the rule doesn't hold. Some day we may have a code of fair salaries for technical men, but in the meantime, you must be your own appraiser.

CLOSING THE DEAL

Finally, it is necessary to learn how to "close the deal." It has been mentioned already that "signing on the dotted line" is the equivalent of this for most salesmen, and it is the critical point of any salesman's effort. The only satisfactory way to do this is to create a desire and then leave it unsatisfied until the agreement is reached.

A very able salesman, who was one of my mentors years ago, told me repeatedly, "Sam, more men oversell than undersell. If they only knew when to stop talking, they would have a better chance to close the deal."

Back in 1929 an engineer who was working at something he didn't like came to me and asked me to get him a technical job. I put him in touch with half a dozen over a two-year period and he "muffed" them all. Finally, in 1930, after the depression had hit us, a position became open near his home. It involved a good salary and it was something I thought he could do. It seemed as if this were *the* chance, so I called him in and made him apply to me for a job. Then we analysed his technique together. There seemed to be two troubles: First, he was not well enough prepared, and, second, he didn't know how to close the deal. In order to remedy the first difficulty I sent him down to a friend of his who was doing similar work and he (the friend) generously told the man all he could about the job. Then he went home, at my suggestion, and boiled down all his experience and his ideas about the job to a twenty-minute presentation. I told him, "When a pause comes in the interview, tell your story, not like a canned speech but genuinely, as it applies to that situation. When you finish you may find another pause. If you do, get up and *leave*." He followed instructions. A committee of four men interviewed him and they asked a few questions. There came a pause and he said to himself (as he told me later), "Well here's where I shoot the works." He did so, and again there was a pause, so he arose and said, "Well, gentlemen, if you want me you can get me on the 'phone." They called him up at nine that night to make sure they would not lose him.

Personnel men sometimes have to be treated differently. They have certain questions to ask and will not be denied, but if you know your story you'll probably know the answers. In any event, *you* terminate the interview. Numbers of men visit my office every day. Only a very few know enough to terminate the interview, and if I try to tell them and intimate that they are taking too much time, they either get scared or feel hurt. I often wonder why.

LOOKING AHEAD WHILE WORKING

There remain two related topics which are pertinent. The first is concerned with the time when you have a job. Many men seem to follow the reasoning of the old farmer who was taxed with the leaks in his roof. "Why don't you fix them, John?" he was asked, "It wouldn't be much work." "Wall," he said, "When it's raining tain't possible, when tain't, tain't necessary." No one can be so sure of his position that he does not need to do two things: First, to study the possibilities in his present position, and, second, to keep in touch with outside activities.

Many men go on the theory that if they do a good job that is all that is necessary, but nothing could be more mistaken. Other people may not be doing a good job, the company may be losing its market, policies may change, top management may change, and with it changes the whole picture which looked so rosy when you started. You may also lose opportunities for two reasons, first, because you have no one to take your place, and, second, because you do not know what is required in the job above you. Some time ago a man was brought in from the outside to fill an executive position when there was an old employee in the place just below, apparently fitted for the job. It seemed so unfair on the part of the company that ordinarily was decent that I took pains to find out the reason and was told that the only reason was that the old employee had not learned to speak in public, whereas the job required, incidentally perhaps, attendance at conferences and meetings where the company needed a spokesman. This is not an advertisement for public-speaking courses, but the incident is told because comparatively little things so often handicap a man unnecessarily.

There is insurance from many angles also in keeping in touch with the outside. It is not necessary always to be yearning for some other kind of a job, but neither does it hurt to keep your abilities before others. This is especially true for engineers who work on specific jobs, be it a bridge, or a factory survey, or the installation of new machinery. How can this be done? Well, it is considered bad form in some circles of society to talk about your job but among men it's always permissible if your description isn't extended unduly. Men like to know what others are doing, but if you talk about your work you must also give others a chance to talk about theirs. You needn't talk much about yourself in doing this and you shouldn't, but your job is another matter.

Beyond this, every one should keep in touch through reading, through conversation, and through professional meetings, with new developments. It is necessary for growth.

Keeping in touch with other businesses and new developments does not necessarily imply leaving your old concern. A highly successful employee of one of our largest corporations confessed that he did not really start to go up until he had had a good offer from another firm and turned it down. Many men have had that experience, but this man let his firm know and it was not long before he was advanced.

PROFESSIONAL ADVANCEMENT

The foregoing applies to most men who work for others, but engineers have both an excuse and means offered them for doing it in that they belong to what is generally called a profession. I will not attempt to define a profession here, but it does imply, as is the fact, that there are others of similar training and experience and that these have joined together to study common problems, to develop standards of training and performance, and to safeguard the ethical bases of the occupation.

I have known men who derided or ignored their professional societies, although, I am glad to say, not frequently; but these organizations are really of tremendous benefit in stimulating new thinking, in providing a common meeting ground for men of like interests, and in the establishment, even though sometimes in an elementary fashion, of standards of performance and training.

Moreover, they are a big help in making possible the professional and intellectual growth without which a man of professional status will retrogress. There is no such thing as standing still. Either we keep our minds active and flexible and keep abreast of new developments, or we fall behind. It is not easy to keep reading new professional literature, especially after a hard day's work. Neither is it always a pleasure to attend meetings, when they are not concerned with our particular tasks, but new ideas come that way—encouragement from the experience of others, facts which are useful when we least expect them.

It may seem a little ironic to go from this to social pleasures but social activities are also important, especially if they take the form of relaxation. Here again it is a case of keeping your mind flexible and adaptable as well as learning to deal with people.

I am not going to duplicate the endless success stories it is possible to read, but a well-rounded man is more able to meet new emergencies, and, regardless of what we would like to believe, social activities have been the means of advancement of a host of men. Professional integrity and eminence need not be sacrificed to social eminence, but social contact, sports, hobbies, amateur public service, all offer the means to meet and know others and are enjoyable in themselves.

A good deal of nonsense has been said and written about the development of personality, as if you could have your personality "lifted" like your face; but as we are affected by our environment, we learn to talk with others easily and more fluently, and we should, but sometimes do not, learn the lesson of tolerance.

Some men will come into a room or an office and will immediately make an impression. They seem to have a little something that sets them apart, that makes others remember their names. It isn't height or weight or ugliness or beauty, despite all the advertisements. It's a man's sureness of himself or his individuality that distinguishes him from the rest of the herd. Such a man finds opportunity because he is remembered. Do people say about you, "What was the name of that man we saw last Friday?" or do they say, "Remember that man Jones we saw last Friday?" It's very much up to you; and your career, if not your happiness, may depend on it.

FINDING AND HOLDING A POSITION

A Check List for a Standard Technique

In Looking for a Job:

Write out an experience record.......................☐
Analyze it according to functions...................☐
List your personal qualifications....................☐
Combine these into an effective record for presentation. ☐
Decide on functions you have performed best and liked best...☐
Decide on geographical location....................☐
Select fields or areas of work, such as industries......☐
List desirable employers in these fields of work.......☐
Plan your approach: (1) In person ☐ (2) By mail ☐ (3) Otherwise ☐
Follow up your contacts...........................☐
Restudy your technique (in light of last two items)..☐

After You Get a Job:

Analyze your job.....................................☐
Study the jobs that lie ahead of you.................☐
Study your coworkers...............................☐
Make outside acquaintances.........................☐
Develop your social life.............................☐
Plan your reading...................................☐
Join professional organizations......................☐
Study allied fields..................................☐
Plan and develop hobbies...........................☐

SUGGESTION SYSTEMS

The Systematic Cultivation of Employees' Suggestions by Individualistic Methods

By Z. C. DICKINSON[1]

THIS PAPER deals with the positive and constructive ideas of workers about products and methods in the establishments where they work. In general these are distinct from the ideas of employees concerning the staple, controversial, collective issues of wages, hours, working conditions, and rights of organization on the one hand, and adverse criticism of tools, foremen, and fellow-workers on the other. Yet these three classes of ideas in practise cannot be sharply differentiated.

Beside this question of eligibility of subject, there is the problem of eligibility of persons. In general this paper is concerned with the ideas of the "rank and file" or common workers in shop or office or salesroom, who are neither supervisors nor salaried specialists. Obviously, the supervisors and others of equal status have always been paid largely for brain work. But here again the distinction is only relative, for the same intolerance of unsolicited advice from inferiors, which is called "foreman resistance" to ideas from the common workers, tends somewhat to prevent officials at each level from receiving the best thought of their own inferiors. Hence, many suggestion plans make foremen and other officials eligible for special recognition, with reference to proposals on matters outside their normal responsibilities.

TYPES OF SUGGESTION PLANS

Formal plans for eliciting, appraising, and utilizing employees' suggestions imply an appraisal committee, containing responsible representatives of the management—also, perhaps, representatives of the common workers—which committee receives the ideas, either directly from the suggester or through some intermediary other than his immediate supervisor.

Within the realm of formal plans in this wider sense, we may readily distinguish some other subsidiary categories: (*a*) Individualistic, i.e., systems which appeal chiefly to the individual self-interest of the potential suggesters, and (*b*) collectivistic, or those which appeal more to his interest in his worker-group, trade union or otherwise. In general the individualist plans lean most heavily on pecuniary incentives, and the collectivist schemes rely more on non-pecuniary motivation, though there is considerable overlapping. In not a few establishments all manner of materialist and honorary appeals are made in both individualist and collectivist fashion at once.

The objectives sought through any suggestion scheme are of two general sorts, which I have called "technical" and "morale" benefits. (1) The technical worth of a suggestion does not depend upon who makes it—employee, boss, customer, or complete outsider. Under special conditions the idea may be patentable and thus it becomes the property of the inventor. (2) The "morale" effects of the whole suggestion process, on the other hand, are peculiar to the suggestions of employees of the establishment to which the suggestion refers. These "morale" benefits, in turn, are of three main sorts: (*a*) Provision for better ventilation of criticisms and grievances; (*b*) assistance in identification of employees who are capable of holding better jobs; and (*c*) increase in the knowledge and interest of the suggester in his work.[2]

SUGGESTIONS IN ABSENCE OF PLAN

What is the suggestion situation likely to be in the absence of a formal plan, other things being equal? A study of the notions which lead to the adoption of formal systems shows that many managers who have had experience with informal methods do not accept all the implications of the proverb, "You can't keep a good man down." But in order to form a sound judgment on what results may be attributed to suggestion schemes we need much more information than is now available on corresponding phenomena in plants which are similar except that some use, while others do not, formal methods of dealing with employees' ideas.

A related question is whether small establishments, in which the top boss may be personally acquainted with all workmen, has any real use for formal schemes, either for suggestions or for employee representation. The National Industrial Conference Board's inquiries indicate that these latter devices are relatively much more common in plants of more than 200 employees than in smaller units; but this finding does not prove that they are not needed by the small fry, for it may be that new and better management methods make their way more rapidly in larger than in smaller plants. The few cases of suggestion schemes in plants of less than 200 workers into which I have inquired have not seemed very satisfactory except while they were new brooms, sweeping clean.

STATISTICAL INFLUENCES ON VOLUME OF SUGGESTIONS

In the individual-reward schemes which have operated for ten years or more, what volumes of proposals have been secured, under what conditions?

Since 1926 I have been in correspondence with persons acquainted at first hand with the operations of perhaps 50 or 60 of these systems, and I have collected comparative statistical data for one or more years from 29 companies. Table 1 exhibits samples of this statistical information, other details of which have been published elsewhere.[3] The data are not thoroughly comparable, even from year to year within the

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[1] Professor of Economics, University of Michigan, Ann Arbor, Mich.

Contributed by the Management Division for presentation at the Annual Meeting, New York, N. Y., Dec. 3 to 7, 1934, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

[2] A section dealing with the history of suggestion systems has been omitted at this point in this condensation of Professor Dickinson's paper.—EDITOR.

[3] See my "Suggestions From Employees," Michigan Business Studies, vol. 1, no. 3, Ann Arbor, 1927; "Suggestions From Workers: Schemes and Problems," *Quarterly Journal of Economics*, vol. 56, August, 1932, pp. 617–643; "Suggestion System Operations, 1926–31," *Personnel Journal*, vol. 12, June, 1933, pp. 16–22; P. L. Stanchfield and Z. C. Dickinson, "Suggestion Systems, 1932 and 1933" (unpublished as yet).

Citations to other literature on suggestion schemes are given in these papers, though I have not compiled nor seen reference to any exhaustive bibliography of the subject.

TABLE 1 COMPARATIVE DATA ON SUGGESTIONS IN 26 ESTABLISHMENTS

(Annual basis)

											Women			
Estab. No. (1)	Industry, location (2)	Size[1] (3)	Period (4)	No. of employees, as per cent of no. in 1929 (4*a*)	Total man-hours worked, as per cent of 1929 (4*b*)	No. of suggestions per 1000 employees (5)	Per cent awarded[2] (6)	Average payment per awarded suggestion[3] (7)	Lowest and highest awards (8)	Number of suggestions per suggester (9)	Per cent of total employees (10)	Per cent of total suggestions (11)	Per cent of total awards (12)	Employee representation (13)
2	Rubber manufacturing, Mid-West	Large	1926–29	...	..	170	24	10.61	5– 800	...	17	..	..	No
			1930	75[6]	..	197	24	15.00	5– 500	...	17	..	...	...
			1931	63	..	250	26	8.40	5– 100	...	17	..	..	Yes
			1932	57	..	200	23	8.60	......	...	..	..	..	...
			1933	61	..	181	23	13.85	......	...	..	..	..	...
5-*a*	Electrical manufacturing, East[4]	Large	1926–29	...	..	294	33	15.81	5–1200	1.6	15	6	4	Yes
			1930	...	..	384	34	14.45	5–1000	...	..	..	..	...
			1931	...	..	299	34	12.25	5– 350	1.8	13	7	4.3	Yes
			1932	...	29	308	35	9.15	......	...	..	..	..	...
			1933	...	29	130	29	9.20	......	...	..	..	..	...
5-*b*	Electrical manufacturing, East[4]	Medium	1926–29	...	..	219	31	10.09	5– 150	1.7	40	26	18	Yes
			1930	...	..	392	29	9.70	5– 150	...	..	..	..	...
			1931	...	..	334	24	10.90	5– 100	1.5	42	25	15	Yes
			1932	...	43	...	35	6.30	......	...	..	..	..	...
			1933	...	48	...	28	5.90	......	...	..	..	..	...
6	Electrical manufacturing, Mid-West	Medium	1926–29	...	..	1518	45	No cash	No cash	4.8	32	9	12	Yes
			1930	...	..	1818	45	No cash	No cash	5	..	..	..	...
			1931 discontinued											
8	Paper manufacturing, East	Medium	1926–29	...	..	1145	28	4.28	2– 500	...	48	11	11	Yes
			1930	86	..	533[5]	15	6.67	5– 100	...	..	..	..	...
			1931	66	..	410	19	7.72	5– 100	1.8	48	9	2.8	Yes
			1932	...	..	138	19	5.60	......	...	..	..	..	...
			1933	...	..	50	16	5.41	......	...	..	..	..	...
18-*a*	Chemical, East[4]	Medium	1927–29	...	..	540	23	11.00	2–1165	2.8	32	6.9	5.1	Yes
			1930	...	..	844	20	13.97	2–1000	3.2	37	7.9	6.7	Yes
			1931	...	..	481	29	8.79	2– 138	2.7	31	4	9	No
			1932	...	..	493	25	10.83	......	...	..	..	..	...
			1933	...	..	420	25	10.24	......	...	..	..	..	...
18-*b*	Chemical, East[4]	Large	1927–29	...	..	219	38	6.39	1– 200	...	24	..	2.4	No
			1930	...	..	388	31	5.81	1–1000	...	20	..	4.4	No
			1931	...	..	317	27	7.37	1–1000	...	21	..	3	No
			1932	...	..	211	32	4.61	......	...	..	..	..	...
			1933	...	..	252	34	4.65	......	...	..	..	..	...
19	Public utility, Mid-West	Medium	1926–29	...	..	306	27	7.50[7]	0.50– 850	...	17	..	..	Yes
			1930	91	..	200	27	8.75	0.50– 305	...	..	..	..	Yes
			1931	...	..	200	25	5.30	5– 10	...	..	..	..	Yes
			1932	78	..	185	7	6.00	......	...	..	..	..	...
			1933	82	..	275	7	7.25	......	...	..	..	..	...
25	Department store, East	Large	1927–29	...	..	70	17	4.50	2– 25	...	60	..	..	No
			1930	104	..	85	13	4.60	2– 25	...	..	..	..	...
			1931	124	..	37	23	4.09	2– 25	...	60	..	..	...
			1932	119	..	60	20	3.46	......	...	..	..	..	...
			1933	121	..	75	16	3.52	......	...	..	..	..	...
26	Life insurance, East	Large	1929	...	..	20	34	9.00	......	...	77	..	..	No
			1930	...	..	19	37	8.13	......	...	78	..	..	...
			1932	...	..	15	50	7.71	......	...	..	..	..	...
			1933	...	..	16	42	7.31	......	...	..	..	..	...
27	Machinery manufacturing, British	Small	1926–29	...	..	2884	40	3.50	0.60– 49	8	Small	..	..	Yes
			1930	...	..	5613	37	2.55	0.60– 15	...	Small	..	..	Yes
			1931	...	..	5430	35	2.13	0.60– 49	...	..	..	..	Yes
			1932	83	78	6460	35	2.02[8]	......	...	..	..	..	...
			1933	93	91	5850	32	2.16	......	...	..	..	..	...

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[1] "Large" = 5000 or more employees, "medium" = 1000 to 5000; "small" = under 1000.

[2] Or "accepted" i.e., given some sort of cash or honorary award. In some cases a suggestion receives an award without being actually put into operation.

[3] Total payments during year (including regular, special, and supplementary prizes) divided by number of suggestions awarded during the year.

[4] 5-*a* and 5-*b* are two plants of a single corporation, likewise 18-*a* and 18-*b*.

[5] Standard of acceptance raised, April 1, 1929.

[6] This index is calculated with the average number of persons on the payroll in 1929 used as base. In earlier reports, the per cent of the number in the preceding year was given.

[7] Averages for 1926–1930, inclusive, obtained by adding total of cash awards and potential value of "merit-mark" awards, and dividing by total number of suggestions given either type of award. For years after 1930, only cash awards are averaged.

[8] British payments converted into dollars at the rate of 25 cents to the shilling.

same establishment, and, of course, many of the most important results could not be shown by even the most refined statistical analysis. Beside the limitations of this table, which are indicated in the footnotes, it may occasionally happen that an employee makes an invention or other improvement which he is able to exploit outside the suggestion system, and thereby earn even more than is shown in the table as the maximum payment for his establishment.

Interpreting the figures of Table 1 in the light of such other information as is available, in which types of situation are the largest numbers of suggestions per potential suggester secured? Column 5 indicates the great variations between still lower figures than the 15 to 20 per *thousand* employees in a life-insurance company (No. 26) and the average of five to six suggestions per *single* employee in a British metal factory (No. 27). No doubt the outstanding cause of these differences is variations in the managerial personnel and techniques which are applied to the operation of the system. In some degree these factors would be reflected in the total expenditures per employee for operating the systems; for satisfactory results cannot be secured without investment of funds in publicity devices and above all in high-grade committeemen and secretaries and investigators, who assist the suggester to express and elaborate his idea, appraise it carefully, and explain to him its merits and limitations.

PAYMENT

Another leading factor in the volume of suggestions, of course, is the total policy as to payment. Columns 5, 6, 7, and 8 give indications of this policy, within each concern, from various angles. If the management desires to encourage suggesters by giving awards for all proposals which show any keenness of mind, then many workers learn that the hurdle is not too high for them, and a large volume may be secured (column 5), of which, say, 40 per cent or more may be awarded (column 6). The average payment per "awarded" suggestion (column 7), however, in this case must be low; moreover, the minimum payment (column 8) will be low. The maximum total reward paid for any one suggestion (column 8) makes fine material for headlines; it appeals to the lottery customer who lives in every person. Only large plants, however, in which small unit savings may be utilized through many repetitions, are able to pay $1000 or more as a single suggestion prize; and even there the argument has some force that prizes should be proportioned in part to the ingenuity and care and effort displayed by the suggestion, rather than according to the rate of production of the part affected.

NON-PECUNIARY INCENTIVES

Several plants have experimented with individualistic appeals without cash rewards. One such incentive is notation of each suggestion and its value on the suggester's employment record, where it is supposed to be a factor in determining his retention and advancement. Establishment 6, manufacturing electrical equipment with two or three thousand employees in the '20's, obtained very striking results for many years without paying cash rewards. It did, however, distribute annually "token" presents of jewelry and other merchandise, the value of each present being roughly proportioned to the total value of the recipient's suggestions during the year; and also it made a feature of the notations on service records.

Another very powerful incentive, which may be employed with or without cash rewards to individuals, is favorable publicity, through plant paper and otherwise, for the makers of the best suggestions. Many people who are otherwise politically conservative—directors of research organizations, for example—as well as many enthusiasts over "solidarity of labor," deprecate any such "invidious distinctions;" but the Bolshevists in Russia have used honorary citations as rewards and incentives on a very large scale—for constructive suggestions from common workers as well as for all manner of other supposedly meritorious acts.

SEX AND OCCUPATION

Does the table indicate other causes or effects, related to the mere number of suggestions? If it were extended to include all similar data which I have collected, we should have some further reason to suspect that manufacturing and public-utility employments are more fertile fields for suggestion schemes than are stores and offices. In fact, some of my factory correspondents have observed that white-collar employees contribute "less than their share" of suggestions (except in special circumstances, such as those of the office boys in establishment 27). Columns 10, 11, and 12 show a very marked difference between the sexes as to both quantity and quality of suggestions. The percentage of suggestions submitted by women is invariably much lower than the percentage of women among all employees; and in most cases a smaller percentage of the suggestions from women win prizes than is the case among the suggestions from men. Perhaps the women do as well as men within the same age and occupational categories; only fragmentary analyses of these latter factors have yet been made.

DEPRESSION

Various other influences might be studied statistically, for example, relations between mental test scores and quantity and quality of suggestions. I shall allude here to only one among this remainder—the effect of business depression. I have not tried to collect and analyze data with reference to earlier periods of severe unemployment, but the figures supplied from 22 plants provide a basis for making some preliminary generalizations on the history of suggestions during the dark years 1930–1933, compared with earlier and better times in the same firms. Samples of these statistics are given in Table 1. Columns 4*a* and 4*b*, indicate the severity of the depression in plants from which such information is available. The following discussion refers to 29 companies which were operating suggestion schemes in 1926—all these systems established at least two years prior to 1926.

The outstanding depression phenomena in these systems were a surprisingly low mortality among the schemes which were operating in 1929; a rather marked rise in volume of suggestions per eligible employee in 1930, followed by declines through 1931–1933; and lesser declines in the average payment per adopted suggestion during these last three years.

My evidence shows definitely, also, that no significant decline occurred in the percentage of suggestions adopted during 1930–1933; and that the decreases in average dollar payments per adopted suggestion, through 1933, were generally quite moderate.

TECHNICAL VALUE OF SUGGESTIONS

The foregoing discussion related most explicitly to quantity. What now may be said of the quality of the common worker's ideas? In this connection "quality" means "technical value," the direct business advantages derivable from the proposals per se.

CLASSIFICATION OF SUBJECT MATTER

Some presumptions as to the technical values in question are supplied by the classifications according to subjects which many firms make up annually; and very likely much more could be learned from them if the nomenclature and classification procedure were made more nearly uniform through cooperative action. About the only generalization I have been able to derive from such summaries is that proposals that are primarily directed toward comfort and convenience of employees, or to relieve grievances, and even schemes for promoting health and safety, usually play rather minor rôles. The suggestion plan itself is the object of some tinkering. Of special interest would be the percentage aimed at new types of business for the firm—new products or customers or even merely slight adaptations from those now in hand. Classification of the *adopted* suggestions would doubtless show significant variations from that of *submitted* suggestions in any one plant and year.

MEASURING "TECHNICAL" VALUE

Such summaries give us a bit of a start on the fundamental problem of measuring the direct business or "technical" value of a suggestion, which is a problem of real concern, even in collectivist schemes which do not pay individual cash rewards. Clearly there is considerable variation among the classes in the practicability of accurately estimating such value.

In most cases, perhaps, accuracy of appraisal is an economic question—it could be refined almost indefinitely if the results warranted the expense of such appraisal investigations. The vast majority of "adopted" suggestions are paid the minimum award, say one to five dollars; and in such cases the officials undoubtedly feel that refined cost studies would not be warranted. All told, it is doubtful if more than ten per cent of all adopted suggestions can be appraised objectively (economically speaking), even in large mass-production plants which are bristling with engineers and accountants. In organizations where standard practises and costs are not carefully studied, the case is correspondingly worse; for cost data will be lacking on both the old and the new ways.

These difficulties are evidently not fatal to the continued operation of many suggestion schemes, though they have been rocks on which numerous brave ships have foundered. If the profit attributable to the suggestion cannot be determined down to the last cent in a manner satisfactory to all parties, at least agreement can generally be reached as to whether the first year's saving is nearer to $10, $50, and so on. Most suggestion committees do, I think, establish, say, half a dozen broad classes of merit, into which they classify suggestions without attempting to determine just how high or low they rank within their respective classes. An important mitigation of these difficulties is provided by annual reviews of adopted suggestions, and supplementary rewards for any which have proved more remunerative than was anticipated at the time of adoption.

Side-lights on the order of magnitude of the "technical" values of employees' suggestions are afforded by comparing the reward payments with the wage bills, and by the numbers of patents emerging from suggestions. For each of the concerns in Table 1 we may readily compute the total annual payments in suggestion rewards per thousand employees on the payroll. In establishment 1, for example, during 1926–1929, an average of about $580 per thousand employees was so paid out (column 5 × column 6 × column 7). This is 58 cents a man a year. In other establishments the figure is larger; and in nearly all cases it is supposed that the direct value of the suggestions is ten times or more the rewards; nevertheless it is clear that the workers were producing a great deal more with hands than with heads. I have also made some inquiries as to patents emerging from suggestion boxes and from union-management cooperation; they appear to be very few indeed. There is no positive evidence, therefore, from a great variety of long-tried schemes, that the mass of workers are immediately capable of any significant number of revolutionary technological or business-methods improvements.

DETERMINING REWARDS

In view of the difficulties cited here, would it not be best to make all appraisals only in the retrospect—to wait on experience with each adopted suggestion? This query brings us to other problems of payment for ideas. A deferred-appraisal policy would not satisfy most suggesters, to whom a bird in the hand is worth several in the bush. Prompt preliminary appraisal is practically necessary; and also prompt payment of most of the ultimate reward. This means that some suggesters are bound to be overpaid, from a purely commercial standpoint; and here is a reason or excuse for some underpayment for the exceptionally profitable suggestions.

In a predominantly individualistic system the reward policy has two principal phases, according as it deals with major or minor adopted suggestions. The great bulk of awards in the schemes for which we have data are under ten dollars; and we may infer that many or most of the smallest payments are regarded by the managements as "welfare" expenditures rather than as purchases of inventions. The few higher awards have much more of the inventor-royalty aspect, and it is these with which we are just now concerned.

Naturally, the first query is, what is the probable *net* saving accomplished by the suggestion? From the gross benefit must be deducted, to begin with, the expenses required for the installation of the new design or method, which alone often prohibit the adoption of very promising ideas. And then some part of the company's expenditures for wages, equipment, and supplies in the operation of the suggestion scheme itself should be recovered before the good suggestions may be said to earn net savings. How much of this general expense should be allocated to a particular adopted suggestion, however, is a puzzle.

One method of dealing with the issue of payment (and with the related difficulties of measuring the saving attributable to a given suggestion) is the prize-contest principle. When a fixed series of prizes is offered, such as $100 for the best, $50 each for the two next best suggestions submitted during a given period, then the judges have only to determine the order of merit of the few best ideas. They are not assigned the more difficult task of appraising the absolute value of each project. Some such schemes have been very effective in securing quantities of suggestions; and very likely their quality may average as high as in most other plans. But obviously the principle of paying for each suggestion what it is individually worth makes a forcible appeal, and so the majority of suggestion plans purport to follow this policy, perhaps in combination with some special contests for fixed prizes.

Supposing that a routine is established for making an estimate of the saving to be accomplished by each adopted suggestion, a further step which naturally occurs to many engineers is to plot a curve, showing relation of reward to saving, and thus to make the amount of reward automatically follow from the estimated saving. Many schemes purport to pay a reward equal to ten per cent of the saving; and in some mass-production plants, smaller percentages are paid on large than on small savings.

Paying diminishing fractions of increasing savings is a principle which has a more solid foundation in equity than is apparent at first glance; for the improvements which run into big money are apt to be small unit savings, perhaps discovered and reported with little or no effort or ingenuity on the part of the suggester, which happen to apply to articles which are turned out by the hundred thousand. Many conscientious managers feel strongly that rewards should be proportioned, in part, to the effort and mental quality displayed by the suggester. On the other hand it may be urged that a straight percentage of saving has two important recommendations: (1) Large rewards give publicity to the suggestion scheme of unrivaled effectiveness, and (2) payment strictly according to profit results tends to direct suggesters' attention to changes that will produce profits.

As already intimated, the query, What fraction of the saving is proper for the reward? is entangled with the problem, What are the proper charges to be deducted from the gross saving in order to arrive at the net saving of the individual suggestion? I assume that the ten per cent figure which is a common basis of American awards usually means ten per cent of the estimated first year's gross gain, minus only the "out-of-pocket" cost of installing whatever new apparatus is required for putting the suggestion into effect. The suggestion secretary adds up all such alleged gains, deducts the ten per cent paid to the suggesters, and the remaining 90 per cent seems to be a gain of tens or hundreds of thousands of dollars, against which the salaries of the secretary and his clerk are rather trifling expenses. The suggestion system appears handsomely profitable to the company. This sort of showing, I imagine, induces a certain tolerance in the various auditors who scrutinize the computations of the gains; so that these estimates of total savings may frequently be optimistic, though there is considerable variation among companies as to such standards. And if account were carefully taken of all the costs of operating the suggestion system, including bits of "company time" of committee members, suggesters, supervisors, and experts who have to be consulted, and the payments made for the mass of minor suggestions, it seems possible that the suggesters as a group get nearer 200 than 10 per cent of the real net gains directly accomplished by all adopted suggestions.

Makers of the best suggestions, however, may plausibly argue that the whole cost of the system should not be assessed against the gains produced by their own, clearly profitable, ideas; that the investigations and payments relative to the 99 per cent of poorer proposals are educational or welfare or back-slapping work, which should be separately financed, if carried on at all.

"MORALE" EFFECTS—TOTAL NET BENEFITS

What may be said in behalf of a policy of low minimum standard of rewards? This query is bound up with a larger one, namely, What are the natures and magnitudes of the indirect effects of suggestion schemes—the "non-technical" or "morale" and educational results?

The principal functions which these systems may perform, apart from the production of profitable new ideas are (1) ventilating dissatisfactions, (2) discovering bright workers for promotion, and (3) increasing knowledge and interest in work. The intangible costs include the envious and disappointed and resentful attitudes of suggesters whose ideas have been rejected, dissatisfaction of some prize winners with the amounts of their prizes—in short, every detail of the plan and its operation is susceptible to unfriendly interpretation and propaganda. In some cases aspiration to a prize may distract a worker from attention to the job he is capable of doing, and absorb him in some project whose impracticality he is unable to recognize.

The grievance-ventilation function is historically important in suggestion schemes, for they have often had to serve as the only sorts of employee representation in their plants. And the zone between mere complaints and positively constructive suggestions is so broad that their problems overlap considerably, in every establishment. With reference to the placement function, the employee's total record as to quantity and quality of suggestions surely is worth considering, along with other particulars, when there is a possibility of changing his rate or job; yet obviously a cash reward for his suggestion is often—perhaps nearly always—more suitable than an increase in his rate of pay, if each good suggestion is to be immediately rewarded at all. An alert suggestion secretary not infrequently is able to assist in improved placement of suggesters—by transfer, for example, if not by rate increase or promotion.

The third non-technical type of benefit—increasing knowledge and interest in work—appears to be of great potential importance, especially if the suggestion department is either part of the personnel division or works closely in touch with educational and placement officials. A background of industrial psychology will very usefully supplement these people's practical skill in dealing with the innumerable interests and capacities that are present in every working force, and which may be revealed in the suggestion processes. They can tolerate and moderate the few cranks, discover and utilize the few geniuses, and, above all, they can assist the mass of authors of amateurish suggestions to learn more about subject matter with which their suggestions deal. As part of the plant's education and training program, a fifty-cent or dollar reward for a suggestion which evidences some study on the suggester's part may be widely approved on the same grounds as bonuses for steady attendance of classes; whereas if we call that fifty cents one of the rewards for *adopted* suggestions it cheapens the system of prizes for really novel and profitable suggestions.

The good chance of getting a small bonus and the slight chance of winning a real prize are potent instruments in the hands of such educators as I am supposed to assist in operating the suggestion scheme; and these premiums, along with various arts of publicity, may enable them to get practically the whole working force to submit to their tuition by becoming suggesters. And surely many, if not all, of these suggesters may be made better informed, more skilled, more productive, and happier workers—especially if serious attempts are made to find the job which the worker most nearly enjoys.

BETTER SUPERVISION AS SUGGESTION SYSTEM

If there is any importance in this educational aspect, then we are now in a better position to deal with the view that, if the foremen and other supervisors are doing their jobs well, there is no real occasion for a suggestion scheme—in fact, that such a scheme is a vain effort to dodge the responsibility for good supervision. The emphasis which all accounts of suggestion plans inevitably place on "foreman-resistance" gives much color to this criticism; and no doubt ability to utilize the mental capacities of each of his men is a vital point of good foremanship. I agree even further with these critics. The foreman scarcely needs a fund of money rewards with which to bribe his men to think; he has at his command abundant other incentives wherewith to invite their intelligent cooperation; and a program for improved supervision should frequently or always take precedence over the development of a formal suggestion plan. I think the latter is best regarded as a sort of functional foremanship. Like other specialized functions, such as hiring and rate setting, it cannot be well carried on without the hearty cooperation of the line supervisors; and most of them can be made to realize that their total job becomes more manageable when special services and routines are developed to assist them. Incidentally, suggestion routine, like employment routine, tends to check abuses by some foremen of their authority; and cash rewards for good suggestions occasionally provide the most satisfactory treatment of the suggester, who may not for a long while be ready for a better job.

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GEORGE A. STETSON, *Editor*

Calvin W. Rice

VERY real is the danger which besets the leader of an institution, on the one hand to run away with the show so that it ceases to be an undertaking of a group and becomes an expression of an aggressive personality, or, on the other hand, to slip obscurely into a clerical groove, faithfully administering the plans of more forceful persons but contributing nothing of vision, inspiration, or program. Leadership in organizations essentially democratic in nature must avoid these extremes if it is to be successful, for under such leadership the institution becomes virile and effective without falling prey to the vacillations of policy and purpose that are characteristic of groups completely dominated by frequently changing officers devoting such time to their duties as their other interests permit.

For more than a quarter of a century Calvin W. Rice exercised this rare type of skilful leadership in The American Society of Mechanical Engineers. Upon him, more than on any other single individual, its progress and influence since 1906 have depended. With him a new and brilliant chapter in the history of the Society was begun. With his recent death that chapter has closed. But so intelligently did he exercise his leadership that hundreds of members find themselves trained in the responsibilities of their assignments to Society tasks, cooperating in the attainment of objectives which his directing genius coordinated.

It was characteristic of the leadership of Dr. Rice to hold himself in the background, assisting others to carry out ideas which, many times, he had put into their heads. He was quick to capitalize the enthusiasm of those who came to him with programs of service to engineers and to direct it into profitable channels. His first care was to commend the man for his idea. His hearty "Perfect!" spoken or written, always carried conviction and encouragement. It applied sometimes to the idea, sometimes to the spirit in which it was advanced, sometimes to both. It was backed up by real help to initiate or further the project, or, in a tactful and kindly manner, to put it into such shape that its originator was led to see its fallacy or to recast it in a more practical and useful form.

Almost invariably Dr. Rice was able to enlarge the vision of those who consulted or worked with him so that their plans would include the entire engineering profession, or at least larger sections of it than it had been their original intention to embrace. The profession itself he saw in terms of larger social relationships. Indeed, perhaps the greatest single characteristic of his secretaryship was the flowering of the spirit of cooperation, so concretely typified in the innumerable "joint activities" undertaken by engineering societies during the past three decades.

The growth of professional solidarity and consciousness nurtured by this development in what had been largely "technical" societies was not toward narrow class distinction with purely selfish motives of aggrandizement and reward. It was liberal and humanistic in quality and preparatory to still broader growth in related and ever-widening fields. Without diverting the minds of engineers from the very special technical tasks that they alone could perform and in which their obligations to their professional interests lay, Dr. Rice's vision encouraged men to think of engineering as a truly public service, involving grave responsibilities and unlimited opportunities.

He will long be remembered for the uniqueness of the position he established for himself as a result of his service to a cause in which he had infinite faith and for which he possessed rare abilities. For in spite of the fact that he avoided the extreme dangers of the position he held, he did impress his personality on his work, on the men with whom and for whom he worked, and on the Society to which he gave the best years and labors of his life. There are many who never thought of engineering or of The American Society of Mechanical Engineers except in terms of Dr. Rice, but there are many more who, not knowing him personally, will never know how much of him has become a part of the profession and the Society in which his spirit is still alive.

Finding Work—and Holding It

HONEST men approach the subject of finding work with humility. Those who have seldom found themselves unemployed will generally admit that they have had the breaks. Indeed, for most engineers the past few years have offered new, bewildering, and bitter experiences, because, heretofore, engineers in general, while they may have passed from one job to another and even from one kind of work to another, have usually done so because the new position had sought them and because the progress of the country had provided abundant opportunities for them to satisfy their ambitions. In so far as engineering employment was concerned, there existed a seller's market.

It is not surprising, therefore, that the technique of finding work has been neglected by engineers as a class. Particularly post-war graduates, who found the larger industrial firms soliciting their services, sometimes competitively, have had, until these last few years, little experience in finding work in a buyer's market and in conducting a campaign to get a job.

Even in good times, as in bad, there are always men seeking work and jobs seeking men. For this reason men experienced in personnel activities have made a business of sorting out square pegs and round holes, of bringing together the best qualified man and the unfilled job, of giving advice and stimulating self-appraisal, job study, and realistic thinking by men about their jobs and their future. Some of this work has been sponsored by universities as a service to the graduating class; and this has frequently expanded into service to graduates as well. The men who are engaged in these so-called placement activities have developed different methods of approach for the individual, but, in general, these methods are representative of a standard technique. Reduced to writing, this technique seems logical enough and fairly obvious, but the suspicion is that some of the steps are discounted by the seeker for a job, and that these may be the very ones that should be given most serious attention.

Elsewhere in this issue, in an article entitled "Finding Work," this technique is developed. The author of the article, Mr. Samuel S. Board, who has spent years in bringing men and jobs together, prepared it at the request of the Council of The American Society of Mechanical Engineers. The desire has been to help men to help themselves. To insure a wide distribution of the article, it was ordered printed in MECHANICAL ENGINEERING, and will be reprinted in pamphlet form and be available for purchase.

Finding work, however, is only one phase of the unemployment problem. Another is keeping the job. Here it is that Mr. Board's article will be of help to every man. The few sane principles that appear on his "check list" and upon which he enlarges in the article are generally observed by conscientious and intelligent men who are interested in their work and normally ambitious.

Competition grows keener when economies must be made in organizations and whenever the turn of fate adds some particularly competent engineer to the ranks of the unemployed. In the sheltered industries and professions there are still job holders who are withholding opportunities from better men unemployed and who are failing to develop these opportunities to the limit for themselves and their employers. By them the check list should be made out.

To the hardest worker and the most conscientious it has a sobering effect to think "There, but for the grace of God, go I," when an unemployed man crosses his path. It is then, perhaps, that he can most profitably run over Mr. Board's check list and cast up his account with his conscience.

December 3 to 7, 1934

NO FINER tribute can be paid to the memory of Calvin W. Rice than to make the 1934 Annual Meeting of the A.S.M.E. one that will approach the ideals that he held for the success of such activities. The elements of such success are the responsibilities of many persons. Officially they rest upon the Meetings and Program Committee which sets up the program, but back of this committee are hundreds of individuals representing other committees and there are the speakers and authors who provide the technical papers. Fortunately, as can be seen by a study of the advance program printed on pages 695 to 700 of this issue, the quality of this feature of the meeting is of a high order. That it will be profitably presented rests with the authors and the chairmen of the sessions. To insure excellence of presentation the Meetings and Program Committee has spent much time on details and special instructions that have behind them the accumulated experience of the many years it has had in conducting similar meetings.

However, excellence of program and attention to details of performance are in vain if a representative body of engineers does not congregate at the Engineering Societies Building in New York during the week of the meeting. For the papers themselves might be read in office or study as, indeed, they will be. But nothing can take the place of the personal experiences that attendance makes possible. Seeing former acquaintances, making new ones, learning at first hand the problems and program of the Society provide stimulating experiences and fresh points of view.

These matters are hard to assess and we generally think of them in terms of their effect upon us rather than in terms of contributions we ourselves may make. Without self-inflation we can admit that our presence swells attendance and that a large attendance is an important element in the atmosphere of a meeting. But there is something beyond that. Most men will admit that they get a lot out of contacts with other men although they seldom stop to figure out that probably they, unconsciously, have contributed to what some other person carries away as a refreshing experience. It's a grand old custom officially recognized in the list of Society objectives—and the quality of the spirit of such occasions sets the tone of the Society's effectiveness. The days to set aside for the 1934 meeting are December 3 to 7.

"What's Going On"

SINCE the abandonment some time ago of the *A.S.M.E. News*, there has been no provision for publishing accounts of the activities and meetings of A.S.M.E. local sections. This does not mean that the work of these local groups is not important, nor does it mean that the developments in one locality have no interest or application to engineers in other parts of the country. It simply means that ***routine*** reports of meetings are no longer published.

In order that experiences of universal interest may be brought to the attention of sections in other parts of the country, it is hoped that reports will be sent to MECHANICAL ENGINEERING upon which notes for the department "What's Going On" may be based. An example of such a report of general interest relating to the Providence Engineering Society will be found on page 511 of the August issue.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

FLOW THROUGH LABYRINTH PACKING

LABYRINTH packing is extensively used in steam and gas turbines, blowers, compressors, etc. Stodola, in 1905 and later, and Martin, in 1908, for the simple case, and in 1919, for the Ljungström, have presented formulas for the calculation of flow in such a case, but the formulas of Stodola and Martin do not agree with each other and their derivations are not sufficiently clear to show the causes and importance of the differences. Moreover, the development of steam turbines in the last years has been such that none of these formulas is applicable any longer. It is claimed in the present article that a general expression for the calculation of flow through a labyrinth is presented and the magnitudes obtained are evaluated for a number of practical cases.

DERIVATION OF THE LABYRINTH EQUATION

If an amount G of a gas or steam flows per second under conditions of laws of pressure through n nozzles $f_1, f_2, \ldots f_n$ sequence, the following equations

$$\left.\begin{aligned} Gv_1 &= f_1w_1 \\ Gv_2 &= f_2w_2 \\ Gv_n &= f_nw_n \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

hold good, where the respective velocities are

$$\left.\begin{aligned} w_1 &= \varphi_1 \sqrt{\frac{2g}{A}\,\Delta h_1(1+\nu)} \\ w_2 &= \varphi_2 \sqrt{\frac{2g}{A}\,\Delta h_2(1+\nu)} \end{aligned}\right\} \ldots\ldots\ldots\ldots [2]$$

In this equation $v_1, v_2, \ldots v_n$ represent volume magnitudes at the exit from the orifices and $\Delta h_1, \Delta h_2 \ldots \Delta h_n$ represent the amount of heat consumed in the process. The function ν, which for the first approximation is accepted to be the same throughout, is supposed to take care of the influence of the inlet velocity of the individual orifice, the coefficients of efflux φ of the resistance to flow, and the contraction. The following three equations, therefore, hold good:

$$\left.\begin{aligned} \frac{A}{2g}\,G^2\,\frac{v^2{}_1}{(\varphi_1f_1)^2} &= \Delta h_1(1+\nu) \\ \frac{A}{2g}\,G^2\,\frac{v^2{}_2}{(\varphi_2f_2)^2} &= \Delta h_2(1+\nu) \\ \frac{A}{2g}\,G^2\,\frac{v^2{}_n}{(\varphi_nf_n)^2} &= \Delta h_n(1+\nu) \end{aligned}\right\} \ldots\ldots\ldots\ldots [3]$$

From these equations may be derived a single general equation for the flow through a series of orifices following each other:

$$\frac{A}{2g}\,G^2\,\Sigma\,\frac{v^2}{(\varphi f)^2} = \Sigma\Delta h(1+\nu) \qquad [3a]$$

This equation covers both kinds of flow that are met with in the rotary machine, that is the working flow through the blades as well as the loss flow through the labyrinth.

If one looks for the amount G flowing through the labyrinth (the determination of the pressure variation is a different problem) the matter of calculation reduces itself to determining the two sums

$$\Sigma v^2/(\varphi f)^2 \text{ and } \Sigma\Delta h(1+\nu)$$

It should be noted in this connection that both v and Δh may be expressed in terms of pressure p. The expansion in the gap may be assumed to be adiabatic, in which case φ does not cover the matter of loss by friction and applies only to the contraction of the jet. Furthermore, it must be assumed that the velocity is entirely annihilated back of each of the passages so that $\nu = 0$. The physical process of flow through a labyrinth is geometrically represented in the p-v diagram, Fig. 1, where the adiabatic expansion takes place 0 — 1 from p_0 to p_1 in the first passage cross-section This is followed by the introduction of turbulence of the energy of flow at constant pressure continuing up to the terminal state 1′, in turn followed by the adiabatic expansion 1′ — 2 from p_1 to p_2 in the second passage cross-section, etc.

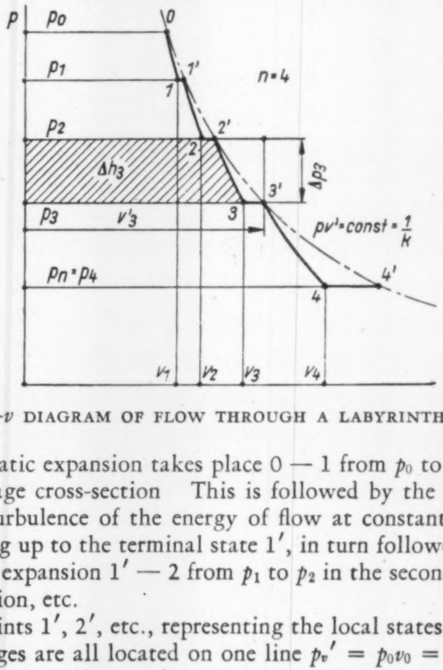

FIG. 1 p-v DIAGRAM OF FLOW THROUGH A LABYRINTH PACKING

The points 1′, 2′, etc., representing the local states ahead of the passages are all located on one line $p_v' = p_0v_0$ = constant $= 1/k$. Values of Δh_i and v_i are expressed by

$$\Delta h_i = A\,\frac{x}{x-1}\,p_0v_0\left[1-\left(\frac{p_i}{p_{i-1}}\right)^{\frac{x-1}{x}}\right] \ldots\ldots [4]$$

and

$$v_i = v_0\,\frac{p_0}{p_i}\left(\frac{p_i}{p_{i-1}}\right)^{\frac{x-1}{x}} \ldots\ldots\ldots\ldots\ldots [5]$$

With these, the first Equation, [3], with $u = \dfrac{(x-1)}{x}$ becomes

$$G^2 \frac{1}{(\varphi_i f_i)^2 p^2_i} = \frac{2gk}{u}\left[\left(\frac{p_{i-1}}{p_i}\right)^{2u} - \left(\frac{p_{i-1}}{p_i}\right)^{u}\right]$$

where k is the ratio of the specific heats. The entire system of equations becomes then

$$\left.\begin{aligned} G^2 \frac{1}{(\varphi_1 f_1)^2 p^2_1} &= \frac{2gk}{u}\left[\left(\frac{p_0}{p_1}\right)^{2u} - \left(\frac{p_0}{p_1}\right)^{u}\right] \\ G^2 \frac{1}{(\varphi_2 f_2)^2 p^2_2} &= \frac{2gk}{u}\left[\left(\frac{p_1}{p_2}\right)^{2u} - \left(\frac{p_1}{p_2}\right)^{u}\right] \\ G^2 \frac{1}{(\varphi_n f_n)^2 p^2_n} &= \frac{2gk}{u}\left[\left(\frac{p_{n-1}}{p_n}\right)^{2u} - \left(\frac{p_{n-1}}{p_n}\right)^{u}\right] \end{aligned}\right\} \ldots[6]$$

We have here n equations with n unknowns, $p_1, p_2 \ldots\ldots p_{n-1}$, and G, but the pressures p_0 ahead and p_n behind the labyrinth may always be considered as given. The solution of these equations by which the values of n unknowns are fundamentally established is difficult. The author therefore adopts a process by means of which the equation

$$G^2\Sigma \frac{1}{(\varphi f_2)p^2} = \frac{2gk}{u}\Sigma\left[\left(1 - \frac{\Delta p}{p}\right)^{2u} - \left(1 - \frac{\Delta p}{p}\right)^{u}\right] \ldots [6a]$$

takes the place of the group of n equations of [6] and summation is replaced by integration under certain assumptions. In this way a single equation with a single unknown G is obtained. Here

$$\Delta p = p_i - p_{i-1}$$

The intermediary pressures p_1, etc., are of minor importance. In what follows, on the right is given a series development for the individual members of the sum

$$\begin{aligned} \frac{2gk}{u}\left[\left(1 - \frac{\Delta p}{p}\right)^{2u} - \left(1 - \frac{\Delta p}{p}\right)^{u}\right] = -2gk \Bigg[\frac{\Delta p}{p} + \frac{3-2x}{2x} \\ \left(\frac{\Delta p}{p}\right)^2 + \frac{7-5x}{6x^2}\left(\frac{\Delta p}{p}\right)^3 + \Bigg\{\left(\frac{2u}{x}\right) \\ -\left(\frac{u}{x}\right)\Bigg\}\left(\frac{\Delta p}{p}\right)^x + \ldots\Bigg] \ldots\ldots\ldots\ldots [7] \end{aligned}$$

It is enough to retain the first member. The summation can be replaced by an integration with a precision which is the greater the smaller and more numerous are Δh and Δp; that is, the more loci of throttling are taken into consideration as compared to the total pressure difference. Since $pv' = 1/k$, then $2gk \frac{\Delta p}{p} = 2gk^2 v' \Delta p$. The expression $v'\Delta p$ represents a right-angle triangle with v' as a base and Δp as the height. The summation comprises all these rectangular triangles from 1 to n between p_0 with base v'_1 and p_n with base v'_n. The integration taking the place of the summation must therefore extend likewise from 0 to n. In this way one obtains

$$\begin{aligned} \frac{2gk}{u}\Sigma\left[\left(1 - \frac{\Delta p}{p}\right)^{2u} - \left(1 - \frac{\Delta p}{p}\right)^{u}\right] &\sim -2gk\ \Sigma_1^n \frac{\Delta p}{p} \\ &= -2gk \int_0^n \frac{dp}{p} \ldots [8] \end{aligned}$$

For the left-hand member of the Equation [6a] the sum of n values has to be obtained

$$\frac{1}{(\varphi_1 f_1)^2 p^2_1} + \frac{1}{(\varphi_2 f_2)^2 p^2_2} + \ldots + \frac{1}{(\varphi_n f_n)^2 p^2_n}$$

The cross-sections of the gaps f assumed to be known vary in some regular manner with the sequence numbers z of the gaps if counted from the beginning of the labyrinth which also means $\frac{1}{(\varphi f)^2 p^2}$. In order to compute approximately this sum by means of integration and to obtain an expression which contains only the initial and final pressure and only the areas of the first and last passages, one may imagine the individual values $G' = \frac{1}{(\varphi f)^2 p^2}$ as being plotted at points 1, 2, . . . n as ordinates G' over the abscissas z, and must than take note that

$$\sum_1^n G' \sim \int_{1/2}^{n+1/2} G'dz = \int_0^n G'dz + \frac{1}{2}\int_0^n dG' \ldots\ldots [9]$$

and, therefore, further

$$\int_0^n G'dz + \frac{1}{2}\int_0^n dG' = -\frac{2gk}{G^2}\int_0^n \frac{dp}{p} \ldots\ldots [10]$$

or

$$G'dz + \frac{1}{2}dG' = -\frac{2gk}{G^2}\frac{dp}{p} \ldots\ldots\ldots\ldots [10a]$$

and when the values for G' are inserted, the following is obtained as a differential equation of the flow through a labyrinth

$$\frac{dz}{(\varphi f)^2} + \frac{1}{2}\frac{d\left[\ln \frac{1}{(\varphi f)^2 p^2}\right]}{(\varphi f)^2} = -\frac{2gk}{G^2}\, p\,dp \ldots\ldots [11]$$

In order to determine the value of G this equation must be integrated between 0 and n. After several other mathematical operations, the following final expression is obtained

$$G = \varphi \sqrt{\frac{gk(p^2_0 - p^2_n)}{\int_0^n dz/f^2 + \frac{1}{f_0 f_n}\ln\frac{p_0 f_0}{p_n f_n}}} \ldots\ldots\ldots [14]$$

which may be considered as a general expression for the leaving flow of a labyrinth containing n places of throttling passages, this holding good for limits of pressure $(p_0 - p_n)$ and a given state ahead of labyrinth $(k = 1/p_0 v_0)$, and under the assumption that the areas of the passages of flow vary in a given manner.

The last section of passage counted in the direction of flow is f_n; f_0 denotes an imaginary cross-section of passage for $z = 0$, and for this may be inserted with sufficient precision the value of the first passage.

The author proceeds next to discuss the application of the formulas to practical cases, and in particular shows a method for the evaluation of the integral in Equation [14]. He next considers the limitations of the validity of the formulas which he derives. He shows that they are valid only when the velocity of flow at no place exceeds the velocity of sound. This is followed by a brief discussion of the formulas of Stodola and Martin previously referred to. With the formula derived, G can be evaluated for various kinds of regular sequence of cross-sections of passages f within a labyrinth. If the leaving amounts for various kinds of changes of f are compared, it will be interesting to consider two cases where a series of falls of f are the same, but the sequence is inverse in one case of what it is in another. This means that in one case the flow occurs in one direction and in another case in the opposite direction. The changes of f are always materially affected by the change of diameter. At first glance it would appear that the amount of flow G_{ai} in the case of inward flow is smaller than the amount G_{ia} in the case of outward flow; that this difference is the smaller the greater the number n of throttling passages, and the greater the smaller the ratio of pressures $\epsilon = p_n$; the value of G_{ai}/G_{ia} must be unity when $f_i/f_a = 1$ and approaches the value of unity the nearer the more f_i/f_a approaches the value of zero. The ratio G_{ai}/G_{ia} must therefore have a minimum value for the average value of f_i/f_a.

The Stodola formula does not recognize the difference in mass flow between two flows in opposite directions. In the above the value of φ must be established by experiment. According to more recent investigations, it should have a value of about 0.8. (Dr. of Engrg. Max Jobst Gercke in *Die Wärme*, vol. 57, no. 32, Aug. 11, 1934, pp. 513–517, 1 fig., *tA*)

Short Abstracts of the Month

AERONAUTICS

The Weir Autogiro

AFTER tests on the new single-seat autogiro, G. and J. Weir, Ltd., a British manufacturing concern, decided to place the model in production on the market early next spring. It was designed to sell at less than £300 if produced in reasonable quantities. The general lines of the Weir machine follow those of other direct-control autogiros, except that for the first time a two-bladed rotor is used. Each blade is 14 ft long and can be folded back over the tail which reduces the overall width to 7 ft 3 in. The fuselage is 14 ft long and the overall is 7 ft 6 in. The machine is driven by a two-cylinder air-cooled motor developing over 50 hp at 3300 rpm and equipped with a two-to-one reduction gear. With pilot and fuel and oil for two and a half hours' cruising, the machine weighs 610 lb. The top speed is stated to be between 90 and 95 mph and the cruising speed about 80 mph. (*The Aeroplane*, vol. 47, no. 6, Aug. 8, 1934, p. 177, illustrated, *d*)

Comparison of Various Types of Aircraft

THE author, inventor of the autogiro, compares the various types of flying machines, which he classifies into three categories. The first comprises machines deriving their lift from the translational motion only; second, machines deriving their lift partly from the translational motion and partly from a relative motion between wings and body; and third, machines deriving their lift mostly from the relative motion between wings and body.

He considers the general efficiency of the various machines, their paying load, utilization, such as ascent and landing, minimum horizontal speed, piloting, and safety. As regards safety he says that the airplane has a static structure that gives it an undeniable advantage. As against this, the very high overloads imposed on its wings by sudden maneuvers or gusts detract somewhat from it. In the case of the autogiro the articulated rotor is only slightly overloaded in the most violent gusts and maneuvers which makes it at least as sound as the airplane.

As to costs he classifies the machines in the following order: Autogiro, airplane, helicopter, and paddling machine. Table 1 was prepared to make a fair comparative estimate of possible performance of the various types of aircraft, the figures being, however, mere estimates. The method of estimating is stated in the original article. (J. de la Cierva, *Aircraft Engineering*, vol. 6, no. 64, June, 1934, pp. 159–160. Compare *L'Aéronautique*, vol. 16, no. 177, February, 1934, pp. 26–30, 1 fig., *c*)

TABLE 1 COMPARATIVE ESTIMATES OF POSSIBLE PERFORMANCE OF VARIOUS TYPES OF FLYING MACHINES

AIRPLANE	
Empty weight, lb	1300
Parasite drag, lb at 100 mph	60
Airscrew efficiency at top speed, per cent	75
Sea-level performances	
Top speed, mph	152
Minimum horizontal speed, mph	35
Landing speed, mph	38
Rate of climb, ft per min at 80 mph	950
Take-off run in still air, yards	60
AUTOGIRO	
Empty weight, lb	1200
Parasite drag, lb at 100 mph	60
Airscrew efficiency at top speed, per cent	75
Sea-level performances	
Top speed, mph	157
Minimum horizontal speed, mph	18
Landing speed	nil
Rate of climb, ft per min at 60 mph	800
Take-off run in still air	nil
HELICOPTER	
Empty weight, lb	1450
Parasite drag, lb at 100 mph	80
Mechanical efficiency, per cent	90
Sea-level performances	
Top speed, mph	150
Minimum horizontal speed	nil
Landing speed	nil
Rate of climb, ft per min at 40 mph	1400
Take-off run in still air	nil
PADDLE MACHINE (CYCLOGIRO)	
Empty weight, lb	1600
Parasite drag, lb at 100 mph	160
Mechanical efficiency, per cent	90
Sea-level performance	
Top speed, mph	110
Minimum horizontal speed	nil
Landing speed	nil
Rate of climb, ft per min at 40 mph	1150
Take-off in still air	nil

APPLIED MECHANICS

The Effect of Contraction on the Turbulence in a Fluid Stream

EXPERIENCE has shown that a large contraction has a steadying influence on a turbulent fluid stream. It is for this reason that modern wind tunnels are often designed with convergent intakes. The present experiments have been undertaken to measure the changes in the disturbed velocities in both water and air streams flowing through a contraction of the same type as that used in wind-tunnel design. The stream flowing into the contraction was made thoroughly turbulent by means of a grid placed in the inlet.

Measurements made on the axis showed that the maximum longitudinal velocity disturbances u_1 were not greatly changed by the contraction, and that the maximum lateral velocity disturbances v_1 were reduced roughly in the ratio of the outlet diameter to the inlet diameter. In other words, the values of u_1/U and v_1/U in the outlet were about $1/m$ and $1/m^{3/2}$, respectively of the values in the inlet, where m is the ratio of the outlet velocity, to the inlet velocity, and U is the local mean velocity. This result differs from that which would be expected from a theoretical consideration of the behavior of a single vortex passing through a contraction. (A. Fage, *British Air Ministry Reports and Memoranda*, no. 1584, Nov. 21, 1932, and Nov. 24, 1933, original 8 pp. and 3 diagrams, abstract from official summary, *e*)

Theory of Similarity as Applied to the Motion of Liquid-Gas Mixtures

THE motion of liquids by means of rising steam or gas bubbles, such as takes place in steam-boiler tubes and evaporator apparatus, is so complicated that its analytical calculation is impossible. Even an attempt to establish the necessary differential equations meets with insuperable difficulties. On the other hand, resort to the point of view of similarity offers the possibility of reducing the variables to a certain minimum number of dimensionless magnitudes. The solution of the problem is then found in the form of a relation between these magnitudes, which usually have to be determined experimentally. The magnitudes themselves are the most suitable variables of the problem and have the form of power functions of the properties of materials and of certain values given by limit conditions.

For the calculation of motion of fluid-gas mixtures the following properties of materials are of interest: Kinematic viscosity ν, density ρ, and capillary constant κ. The first two, measured to a proper degree of precision, apply to both the liquid and the gaseous constituents of the mixture. For pressures which do not approach too closely to the critical point, the forces within the air or steam bubbles may be disregarded as against those exerted in the liquid, and in this way obtain the advantage of having to consider only the physical properties of the latter material. The driving force in the motion of the bubble is the upward push determined by the acceleration due to gravity g. However, since this upward push depends exclusively on the difference between the specific weight γ_d of the steam or gaseous part and the water or liquid part γ_w, the following expression of the upward acceleration may be introduced:

$$b = g\,\frac{\gamma_w - \gamma_d}{\gamma_w}$$

If processes are limited to stationary ones and if it is assumed that the bubbles are generated at the bottom of the tube under consideration, it is necessary for the process to have at least one velocity w and at least one longitudinal dimension d. In all, six magnitudes have to be considered, and their dimensions in technical units may be expressed in the following way in terms of the three fundamental units—kilogram, meter, and second. These are

Magnitude	Symbol	Unit
Kinematic viscosity............	ν	m^2/sec
Density........................	ρ	$kg\ sec^2/m^4$
Capillary constant.............	κ	kg per m
Upward acceleration............	b	m per sec per sec
Velocity.......................	w	m per sec
Length, diameter...............	d	m

It is out of these magnitudes that the dimensionless coefficients have to be built up. According to a general law discovered by Weber, when there are n magnitudes, the dimensions of which are expressed in terms of m fundamental units, there will be $n - m$, or in this case $6 - 3 = 3$ dimensionless coefficients entirely independent of each other. Their selection is more or less arbitrary, but in every instance it is necessary to have three such magnitudes independent of each other. In this case the "characteristic magnitudes" (coefficients) can be obtained in several ways, for example, by differential equations. However, it can be also done by methods such that it is not necessary to establish equations of motion. A method for the selection of the coefficients often used in hydraulics leads to the following:

The Reynolds number............ $R_e = \dfrac{wd}{\nu}$

The Froude number.............. $F_r = \dfrac{w^2}{db}$

The Weber number............... $W_e = \dfrac{w^2 d\rho}{\kappa}$

The Reynolds number is obtained from the ratio of force of mass to the force of viscosity, the Froude number from the ratio of force of mass to the force of gravity, and the Weber number from the ratio of the force of mass to the capillary force.

EQUATIONS OF SIMILARITY

The natural law controlling the process under consideration may be expressed as follows:

$$\Phi\left(\frac{wd}{\nu},\ \frac{w^2}{db},\ \frac{w^2 d\rho}{\kappa}\right) = 0 \ldots\ldots\ldots\ldots [1]$$

where the function Φ has to be determined experimentally. If these ideas are applied, for example, to the rise of an air bubble in an expanded liquid, w is the velocity of upward motion of the bubble and d is the length characteristic of its size, and in the case of spherical bubbles, the diameter. In another form, it is the cubic root of the volume of the bubble or the diameter of a sphere of equal volume. Since the shape of the bubble in the case of a fluid having given properties is determined by its volume, one longitudinal dimension is sufficient.

For the present purpose where it is desired to determine the velocity of rise of the bubbles the expression for the function is not very suitable as w appears in all the three coefficients. Because of this the author selects another group of coefficients such that the factor of velocity appears in only one of them. Here any function whatsoever of the coefficients can be introduced as new coefficients, providing, however, that the three functions are independent of each other. The following may be selected:

$$\left.\begin{aligned} R_e &= \frac{wd}{\nu} \\ \frac{W_e}{F_r} &= M = \frac{d^2 b\rho}{\kappa} \\ \frac{\sqrt[3]{F_r (R_e)^4}}{W_e} &= N = \frac{\kappa}{\rho\sqrt[3]{b\nu^4}} \end{aligned}\right\} \ldots\ldots\ldots\ldots [2]$$

where w appears only in the expression for the Reynolds number. M contains a dimension squared together with the "coefficient of material" $b\rho/\kappa$ which in the case of liquids does not vary much, as the density and capillary forces can each vary only within one order of magnitude outside of the range close to the critical point of the liquid where κ becomes very small and hence M very large. The third coefficient N contains only the properties of the material of which viscosity may vary within very wide limits. Having these coefficients and having solved the expression for R_e, it becomes possible to represent the velocity of rise of bubbles in an unconfined liquid as follows:

$$\frac{wd}{\nu} = \Psi\left(\frac{d^2b\rho}{\kappa}, \frac{\kappa}{\rho\sqrt[3]{b\nu^4}}\right) \quad [3]$$

If the bubbles do not rise in an unconfined liquid but in a pipe of diameter D, it becomes necessary to introduce as an additional dimensionless magnitude the ratio D/d.

Since bubbles in pipes may as a rule be of the most varied sizes and shapes, it is preferable to use the diameter of the bubble as the fundamental dimension of length, and as another dimensionless magnitude characterizing the content of the bubble, the ratio f_d/f_w which is the ratio of the cross-section of the bubble f_d to the cross-section f_w of the liquid. This coefficient, as shown by the following, is closely connected with the specific weight of the liquid:

$$\gamma = \frac{f_d\gamma_d + f_w\gamma_w}{f_d + f_w} \quad [4]$$

In this way the following equation is obtained:

$$\frac{wD}{\nu} = \Psi_1\left(\frac{D^2b\rho}{\kappa}, \frac{\kappa}{\rho\sqrt[3]{b\nu^4}}, \frac{f_d}{f_w}\right) \quad [5]$$

Instead of the actual air velocity calculated from the part of cross-section filled with air there may be introduced the theoretical air velocity $w_{dt} = w\dfrac{f_d}{f_d + f_w}$ which would have been present if it were air alone that was flowing through the pipe. This selection has the advantage in that the amount of air supplied can be determined at once from w_{dt} and the cross-section of the pipe f. The following then holds good

$$\frac{f_d}{f_w} = \Theta\left(\frac{w_{dt}D}{\nu}, \frac{D^2b\rho}{\kappa}, \frac{\kappa}{\rho\sqrt[3]{b\nu^4}}\right) \quad [6]$$

In this way the functional relationship between the coefficients and the content of the bubble or the specific weight of a gas-water mixture in a vertical pipe can be expressed. In general cases, it is also necessary to introduce the mass ratio L/D of the length to the diameter, and a coefficient δ/D expressing the relative roughness of the pipe wall, which gives

$$\frac{f_d}{f_w} = \Theta_1\left(\frac{w_{dt}D}{\nu}, \frac{D^2b\rho}{\kappa}, \frac{\kappa}{\rho\sqrt[3]{b\nu^4}}, \frac{L}{D}, \frac{\delta}{D}\right) \quad [7]$$

Whether or not such an extension is really necessary, only experiments can determine. The measurements made by Behringer (reported in the same issue of the original publication as the present article) have shown that in pipes of from 57 to 82.5 mm in diameter and column 4 to 5.5 m there is a practically exact constant specific weight along the entire height of the mixture. From this it may be concluded that the bubbles acquire their distribution and paths of motion immediately after they are generated, and neither the distribution nor the character of motion change during the entire travel through the column of mixture, at least as long as the decrease of pressure is small as compared with the absolute pressure.

If this observation is correct the influence of the method of introducing the bubbles can be neglected at a height in excess of a few diameters above the place where the bubble has been introduced. The influence of roughness of wall is the less important the smoother the wall and the larger its diameter.

Hitherto the liquid in general has been assumed to be quiescent. If it is flowing, as is the case in pumps and boilers, a new coefficient, namely, its initial velocity, has to be introduced and this can be obtained, as has been done in the case of air, over the entire cross-section and denoted by w_{wt}. Then it is necessary to introduce as another new coefficient the ratio $\dfrac{w_{dt}}{w_{wt}}$ of the two velocities or the Reynolds number $w_{wt}D/\nu$, based on the velocity of flow of the liquid. This gives

$$\frac{f_d}{f_w} = \Theta_2\left(\frac{w_{dt}D}{\nu}, \frac{D^2b\rho}{\kappa}, \frac{\kappa}{\rho\sqrt[3]{b\nu^4}}, \frac{w_{dt}}{w_{wt}}\right) \quad [8]$$

The author next discusses the case where the physical characteristics of the gas are introduced. He imagines that the carrying over of the liquid by the gas occurs somewhat as in the pneumatic delivery of the liquid, and is covered by the present equations. However, where granular solid material is carried with the gas, the coefficient based on surface tension and viscosity of the materials handled cannot be used any more. The consideration of properties of the two materials makes it possible to apply the present ideas to the process of injection in which the liquid is atomized by a stream of gas and the jet of liquid is broken up into droplets.

The author goes into more detailed consideration of the internal-combustion engine and the atomization of the jet of fuel injected into compressed gas. Here the following have to be considered as limiting factors, the diameter D and the velocity w of the jet of liquid, assumed to be cylindrical. As a dependent functional variable characterizing the degree of atomization the average diameter d of the droplet as it exists after the termination of the atomization is used. The effect of gravity may be neglected here, which means that b may be dropped from among the coefficients and instead of coefficients M and N a new coefficient may be used, such as, for example, is expressed in

$$\sqrt{MN^3} = \frac{d\kappa}{\rho\nu^2} \quad [9]$$

If we denote by f the properties of the liquid and by g the properties of the gas, we obtain for the process of injection of a jet of fuel into a gas the following law of similarity:

$$\frac{d}{D} = \Psi\left(\frac{wD}{\nu_f}, \frac{d\kappa}{\rho\nu_f^2}, \frac{\nu_f}{\nu_g}, \frac{\gamma_f}{\gamma_g}\right) \quad [10]$$

From this it would appear that the operation of a pump for any liquid and the water circulation in accordance with Equation [8] present problems with four independent variables, even if the forces within the gas bubble are neglected. If consideration is limited to the case of the same liquid, for example, water at a given temperature, there will still be three independent variables. It is this complicated nature of the problem never before recognized which is the reason why there has not been developed a satisfactory solution of the problem of water circulation in steam boilers. Very many more tests will have to be carried out in order to fill in the "frames" indicated by considerations of similarity. Above all it is necessary to carry out tests with liquids of different viscosities and surface tensions in order to cover the greater range of coefficients. On the other hand, one should not become excessively dismayed by the great number of variables, as it has been found from experience that in the majority of cases the shapes of the functions expressing the coefficients are simple. If the regions to be covered are not too great, the independent coefficients are usually expressed in power products of the coefficients with constant exponents. Often the range of variation of certain coefficients is so small in practise that its influence may be completely neglected.

APPLICATION TO THE TESTS BY BEHRINGER AND SCHURIG

This part of the article is not abstracted here because of limitations of space, as only the briefest reference to the original papers by Behringer and Schurig could be made. (Prof. Ernest Schmidt in *Forschung auf dem Gebiete des Ingenieurwesens*, Research issue no. 365, appendix 2 B, vol. 5, March-April, 1934, pp. 1–3, 2 figs., *tA*)

ENGINEERING MATERIALS

New German Process for the Manufacture of Light Concrete

THIS process was patented by a Berlin construction company in Germany and consists in incorporating into the concrete structure small preformed clay bodies of highly porous character. It is claimed that in this way a concrete is produced which is a good insulator against the flow of heat and sound, has a specific weight of less than 1.5, and can be handled by any present construction machinery including the concrete pump. Its compressive strength is said to be very much greater than that of other types of light concrete and to amount, after mixing, to from 100 to 250 kg per sq cm.

Spherically shaped clay bodies are produced entirely by machinery. To explain the process the author assumes that it is being made on four different floors, the topmost floor containing the track by which raw material, namely, fat clinker clay, is brought in. The material is here subjected to a thorough kneading for half an hour after an addition of about 55 per cent of lignite dust, which latter can be replaced by wood flour. These additions are burned out later in the furnace and serve to create porosity in the clay bodies. Gas-forming chemical materials also can be used to produce porosity.

When the clay with its additions of brown coal or wood flour has been thoroughly worked it goes into a clay cutter located on the third floor. Here the clay is pressed into strips which are then cut into little pieces by another machine. The lumps of clay go through holes in the cover and fall on to a vibrating sieve on the second floor. This sieve, of troughlike shape, is set at an angle so that the little lumps of clay slowly roll downward and thereby assume an approximately spherical shape. From the sieve the clay pieces which are now of various sizes up to 2 cm in diameter go to pretreatment furnaces in which they are subjected to burning for about 40 min. It is here that the pores are formed through the burning out of the lignite or flour-mill additions to the clay. A belt passing through the oven where a temperature of 100 to 300 C prevails carries the clay bodies which, before leaving the furnace entirely, go slowly through a portion thereof where a temperature of about 100 C is maintained. From the furnace the hot clay pieces go through an appropriate opening on to a second inclined vibrating sieve. Here the hot lumps roll in a mass of clay mud and acquire a thin clay jacket which closes the pore outlets. By means of a supply of warm air a rapid drying of this clay jacket is secured. The little spheres with their jackets now go to an inclined rotary furnace about 20 m long and are exposed there to an initial temperature of 300 C which, toward the end of the furnace, rises to 1100 C. In this furnace the clay shapes acquire a dense fully burned clay jacket about $^1/_2$ mm thick. In the manufacture of concrete these clay balls are used in the same proportions as gravel, i.e., are mixed with cement and sand in proportions one-quarter by volume, to which is added 20 per cent of water. The burned clay takes up the excess of water, while the sand and cement cannot penetrate into the clay bodies because of the protection afforded by the jacket. If it were not for the presence of the jacket, the cement would penetrate into the outer pores and this would produce the effect of making the binding mortar too lean.

It must be understood, of course, that actually the machines are not located on several floors, one on top of the other, as has been described above, for the sake of making the general features of the process clear. (Friedrich Huth in *Tonindustrie-Zeitung*, vol. 58, no. 34, Apr. 26, 1934, pp. 418–419, *d*)

Metallization of Press-Molded Articles Made With Synthetic Resins

MANY attempts have been made to produce a metallized surface of such articles by means of the metal-spraying process (Schoop). This has not been uniformly successful to a large extent because, on account of the very smooth surface of articles of this kind, the metal sprayed has only a poor chance of adhering to the surface. It is claimed now that a new method of producing a metal deposit has been developed consisting of dipping the article into a liquid containing simultaneously a solvent medium and a reducing medium. It is said that in all previous processes the application of the solvent medium and reducing medium were made one after the other and not as in the present process concurrently.

The materials in the liquid are so proportioned that the reducing medium is amply soluble in the solvent medium, without, however, preventing thereby the surface attack on the article to be metallized. The action of the solvent medium produces local roughness of the surface and this lends proper anchorage to the deposit which takes place with great rapidity and produces a metal layer closely adhering to the surface of the article. In fact, it is claimed that the layer deposited is often so thick that subsequent electrodeposition is not necessary. The parts which should not be metallized are protected by a layer of varnish. The metal salt solutions, such as chloride of gold or silver, are usually of the 2 per cent to 4 per cent type and permit re-use for a number of times. The process of metallization is said to be substantially, as follows: The article is first polished to a high finish free from cracks and all grease or oil from the surface is carefully removed. The first immersion is into an aqueous solution of hydroquinone. The concentration of the solution and the duration of the dipping depend on the material of the article and must be held in each case within close limits. The use of excessive temperatures in drying must be avoided, as it is apt to produce distortion of the article. After complete drying the article is dipped into a reducing metallic salt solution. If after the first immersion the article is not completely metallized, the process may be repeated. After, at most, three immersions the article should be completely metallized, and after removal of the moisture should show a high finish. (Rene W. P. Leonhardt in *Kunstoffe*, vol. 24, no. 3, March, 1934, pp. 55–56, *d*)

HYDRAULIC ENGINEERING

Fluid Flow in Rough Pipes

A BODY is considered to be hydrodynamically rough when irregularities on its surface affect to a measurable extent the resistance to motion. The effect of roughness on resistance depends not only on the geometrical form of the irregularities but also on the nature of the flow over the surface. In practise, surface roughness does not commonly assume a simple geometrical form, but arises from an indefinite number of irregularities whose size and form cannot be specified with exactness. The resistance of such a surface can only be obtained by measurement. Even when the irregularities have a simple geometrical form, the effect on resistance cannot be predicted theoretically and must be measured.

Experiments are described which show that the resistance of a rough pipe, obeying the square law, arises from the normal components of the pressure on the irregularities constituting the roughness, and not, as in a smooth pipe, from surface friction.

Observation with an ultramicroscope shows that the flow in a rough pipe is much more disturbed than that in a smooth pipe. Evidence is obtained of considerable agitation in the flow near the irregularities, and of the creation of eddies comparable in size with the irregularities. (A. Fage, *British Air Ministry, Reports and Memoranda*, no. 1585, Oct. 17, 1933, original 11 pp. and 13 diagrams. Official abstract, *te*)

INTERNAL-COMBUSTION ENGINEERING

The Supply of Fuel to the Fore-Chamber of the Powdered-Coal Diesel Engine

IT IS alleged that the wide adoption of the powdered-coal Diesel engine is being delayed by lack of reliability in operation, and the author divides the factors affecting reliability into three classes: (1) Exact metering of the coal dust required for each degree of operation and its delivery to the cylinder; (2) the formation, ignition, and combustion of an ignitable mixture; and (3) removal of the residues of combustion. He deals particularly with the auxiliary-chamber process as developed for the Diesel engine by R. Pawlikowski who introduces the powdered coal into a kind of antechamber or auxiliary chamber during the suction stroke of a four-stroke-cycle engine. The fuel and the air of combustion are compressed and preheated in that auxiliary chamber. In this way the delay in combustion is taken care of during the compression stroke. Moreover, in this preparatory process certain phenomena occur which make the fuel more suitable for subsequent combustion. After the proper temperature has been reached, self-ignition and partial combustion take place in the auxiliary chamber and the increase of pressure produced thereby helps to inject the rest of the fuel into the cylinder and burn it there.

An investigation has been carried out in the machinery laboratory of the Technical High School, Dresden, to determine to what extent the partial vacuum in the cylinder occurring during the suction stroke may be used for metering and introduction of the fuel in such a manner as to dispense with the elaborate control machinery which is exposed to a good deal of wear. It is also desirable to inject the coal dust in some such manner as was done hitherto by air injection, utilizing auxiliary air under pressure. The process contemplated is also desired to satisfy the following requirements: (1) Exact metering of the fuel with simple control; (2) retention of the coal dust in the auxiliary chamber up to the beginning of combustion.

As regards metering and control of fuel, it was desired to avoid the necessity of having the coal dust travel through complicated paths, as in devices hitherto made it was the adherence to and attack by coal particles on machine parts that constituted the most important source of trouble. The purpose of the second requirement set forth is to prevent the deposit of unconsumed coal dust in the lubricating oil on the cylinder walls, which also gave trouble.

The original article describes in detail the experimental installation. It was found that it was impossible to prevent the penetration of coal dust into the working cylinder during the injection process by means of valving between the auxiliary chamber and the working chamber. Valving at such a place could not be made reliable because of the high heat and mechanical stresses. Premature penetration of the dust, however, could be prevented by a stream of air flowing into the auxiliary chamber through a small properly dimensioned orifice. The velocity of flow need not be greater than 3 m per sec in order to retain the largest present coal grains; and to create such a stream of air it is necessary to have only a rather light excess of pressure in the working cylinder. The introduction of the coal dust by external air pressure and its mixture with the air carried with it are possible only as long as the pressure in the auxiliary chamber is lower than that of the ambient pressure. It is appropriate, therefore, to employ for the opening of the coal-dust valve that time period at the end of the suction stroke and at the beginning of the compression stroke during which the pressure in the auxiliary chamber, as determined by the velocity of the piston and the cross-section of the orifice, lags (Fig. 3) somewhat behind the increased pressure produced in the working cylinder by the column of air that tends to follow the injected air in its swing, and by the motion of the piston.

For purposes of comparison it has been established in investigating a gas engine by means of an indicator with a weak spring that the time period of increase of pressure in the cylinder from the minimum to the atmospheric pressure for an engine running at 170 rpm was about 110 deg of the crank angle and that the magnitude of this crank angle is practically independent of the minimum pressure attained during the suction stroke. This crank angle of 110 deg in the case of a four-stroke-cycle engine corresponded to the camshaft angle of 55 deg. However, since the increase of pressure is very gradual at first, in the tests the duration of opening of the fuel valve was restricted to 35 deg of camshaft angle, in order to provide a substantial difference in pressure between the auxiliary chamber and the cylinder, this latter being required in order to create a powerful stream of air between the two. The valve *e* in the connecting piece *d* of the experimental unit shown in Fig. 2 is installed in order to provide at the desired instant the connection between the space *d* and the atmosphere, this being done to create an increase of pressure corresponding to the increase of pressure in the working cylinder at the end of the suction stroke or at the beginning of the compression stroke of the actual machine. It became possible to make the increase of pressure comply with the desired law only when a suction pipe *k* about 7 m long has been added to the valve. When the air valve *e* is opened, this pipe, because of the acceleration of the air column, creates at first a slow increase of pressure and then, because of the continuing swing of the air column, a charging up to the external atmospheric pressure that may be even a supercharging. The course of pressure variation in the auxiliary chamber and working cylinder shown in Fig. 3 in the original article has been plotted from the readings of a weak-spring indicator.

FUEL METERING

In order to obtain fuel metering corresponding to the motor demands, it was first of all necessary to find a satisfactory shape for the intermediate chamber which, when placed between the fuel condenser and fuel valve, would provide a uniform suction.

The fundamental problem here is to obtain a mixture of coal dust and air that will move through the piping and fuel valve. The amount of air added in itself does not play any special rôle insofar as the process of combustion is concerned, as it represents only a fraction of the total air taken in by suction. The experimenters conceived the idea of providing, for the control of the air to be mixed with the fuel, a device similar to the carbureter for handling liquid fuels. However, since the process of mixing coal and air has nothing to do with "carburetion" the chamber used for this purpose is referred to in what follows as the "mixing chamber."

The original article describes how a mixing chamber has been built in such a manner as to make it possible to observe what is going on therein. The installation as finally completed corresponded to a motor cylinder provided with an auxiliary chamber having a capacity of 3.6 liters while the motor cylinder had a volumetric capacity of 200 liters. Assuming that 6 cu m of air are needed to burn lig~~nite~~ "electro filter" coal dust with the usual coefficient of excess of air, the dimensions of the experimental unit were such as to require the injection of 20 g of fuel per cycle at full load. The camshaft was supposed to run at 84 rpm and, as would appear from curves in the original article (Fig. 5), this injection of 20 g per cycle with a pressure difference of 0.2 atm between the minimum pressure and the atmospheric pressure occurred quite smoothly. This pressure difference had to be secured in the motor referred to here by shortening the duration of opening of the air-injection valve, which meant giving up the attempt at obtaining the most favorable volumetric efficiency. From the shape of the curves it would appear that the proper functional relationship between the amount of air supplied on one hand and the throttling regulation on the other hand, is obtained either by adjusting the partial vacuum Δp within the auxiliary chamber by operating the air-injection valve; or, for the similar partial vacuum Δp, the variation of the coal-dust supply may be produced by a proper adjustment of the cross-section of the mixing passage *d*.

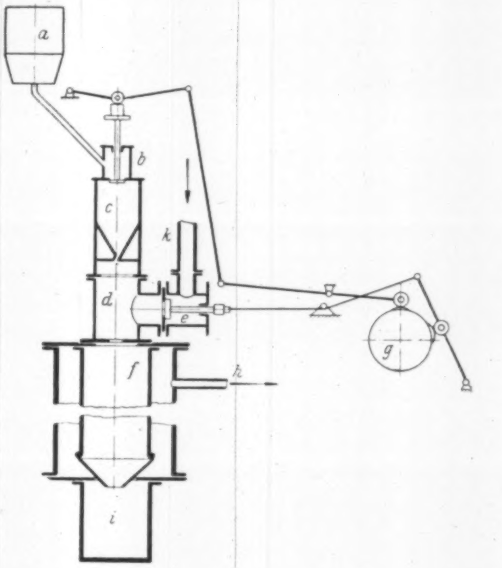

FIG. 2 EXPERIMENTAL UNIT FOR INVESTIGATING THE BEHAVIOR OF CARBON DUST IN A DIESEL ENGINE

(*a* = coal-dust mixing chamber; *b* = coal-dust valve; *c* = supply chamber; *d* = connecting piece; *e* = air inlet valve; *f* = coal-dust separator; *g* = camshaft; *h* = air pipe to the suction pump; *i* = collector vessel; *k* = suction pipe.)

The original article includes a Table 1 with data for four series of tests differing by the adjustment of the fuel valve made so as to observe the "scattering" of the individual injections. The mixing chamber was found to operate best in its present design and dimensioning for the medium range corresponding to about one-half to three-quarters of the full load. In this range the amounts of coal supplied vary by a maximum of 3.8 per cent from the average values, while the variations at full load amount to ±4.8 per cent. It will be difficult to secure a greater precision of fuel metering in the case of a material that is as non-uniform as coal dust. This unavoidable lack of uniformity will have to be offset in the actual machine by a sufficiently large flywheel. Various kinds of coal dust have different delivery characteristics, which means that the mixing chamber will have to be adjusted when passing from one kind of dust to another. The depth of the layer of coal dust in the mixing chamber had no influence on the coal delivery within the limits of variation with the experimental model. Small changes cause a slight variation of the amount of coal delivered but do not materially affect the regularity of operation providing they occur in a uniform manner. On the other hand, with this manner of supplying coal, trouble arose because it depended on the satisfactory operation of the coal-dust valve, which had to be made to prevent coal particles from causing leaks by getting in between the plate and seat.

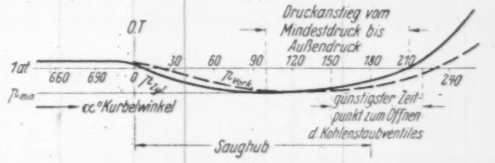

FIG. 3 PRESSURE VARIATION DURING THE CYCLE IN THE AUXILIARY CHAMBER AND WORKING CYLINDER

(*Kurbelwinkel* = crank angle; *Druckanstieg vom Mindestdruck bis Aussendruck* = rise of pressure from minimum to atmospheric; *günstigster Zeitpunkt zum Offnen d. Kohlenstaubventiles* = most favorable instant for opening the coal-dust admission valve; *Saughub* = suction stroke.)

PROCESS OF INJECTION OF COAL DUST INTO THE AUXILIARY CHAMBER

The instant and duration of the opening of the coal-dust valve (the beginning of the rise of pressure in the working cylinder and in the auxiliary chamber at the end of the suction stroke), which must satisfy the requirement that the coal dust shall remain for a sufficient length of time in the auxiliary chamber, has been determined by photography, as the process cannot be followed by the naked eye. In order to obtain as sharp images as possible for the boundaries of the cloud of coal dust being injected into the chamber, it was necessary to use short exposures. This could be done with spark photography in which the spark and hence the instant of taking the picture could be controlled by a shaft operated by the valve itself. The photographs were obtained as shadow images on a light-sensitive paper. The original article gives a series of photographs showing the penetration of the coal dust into the auxiliary chamber under similar conditions (the beginning of the rise of pressure in the working cylinder). These photographs cannot be reproduced for technical reasons. They show that the stream of air flowing upwardly from the cylinder at an angle into the auxiliary chamber produces a turbulence which prevents the separation of the constituents of the coal-dust-air mixture entering the mixing chamber, a separation which could have easily taken place with less air motion in the chamber. It is very important for the proper operation of the motor, therefore, that the passage connecting the auxiliary chamber with the working cylinder be of proper design and dimensions to create the powerful turbulence required. From the results obtained with the experimental installation it is recommended that where the average piston velocity is of the order of 5 m per sec, the cross-section of the passage be not more than $^1/_{306}$ of the piston area, as otherwise sufficient pressure difference between the working cylinder and the auxiliary chamber cannot be maintained conveniently.

It is stated that the photographs show that the jet of air, flowing in a direction opposite to that of the penetration of the coal into the chamber, does what it is expected to do. It is only at a camshaft angle of 42.5 deg that the coal dust begins to flow into the working cylinder and it is important to remember that in the experimental installation, owing to the absence of proper compression, an equalization of pressure between the auxiliary chamber and the working cylinder took place. In a real machine compression at first takes place as a result of the motion of the piston, with the result that the coal dust would remain in the auxiliary chamber until the moment of ignition therein. In these assumptions the rotative velocity of the camshaft remains at 84 rpm so that to 1-deg angle of the camshaft rotation there corresponds a time period of 0.001984 sec. (Dr. of Engrg. Carl Zinner, *Zeitschrift des Vereines deutscher Ingenieur*, vol. 78, no. 34, Aug. 25, 1934, pp. 1007–1010 and a page of photographs, *eA*)

Diesel-Engine Fuels

IN AN address before the summer meeting of the Society of Automotive Engineers, June 17 to 24, 1934, Arch L. Foster, of the editorial staff of *National Petroleum News*, presented a paper on low-cost Diesel fuel, in which he claimed that its availability depends on the ability of the engines to use cracked gas oil.

In arriving at the question of what fuel will be available in largest quantities, the statement was made that straight-run fuel is to be scarce and that cracking is certain to increase because of the probable rigid curtailment of crude production. With scarcity of crude it will be imperative for the refiner to extract from the obtainable crude the largest percentage of the more expensive products. Gasoline will be produced at the expense of any other product, except for the small proportion of lubricants made.

Since the gas-oil fraction produces greater yields of gasoline with less trouble and lower costs, it will be cracked in preference to any other fraction. One source of a Diesel fuel will be the "re-cycle stock" which has reached the point of being less desirable for further cracking. This material will be available in far greater quantities than straight-run gas oil and its price will be appreciably less.

Another potential source of a cheaper Diesel fuel, one which is now being utilized to some extent, is the so-called pressure-distillate bottoms, that portion of the light cracked material from the cracking still which has too high a boiling point to fit it for motor fuel. From this it is evident that the most prolific source of the cheapest heavy-oil-engine fuel is the same as the carbureted fuels, and as such would tend to utilize more efficiently the crude being produced. This fuel will be unsaturated chemically, more or less aromatic, high in carbon-hydrogen ratio, and heavy in gravity. The refiner's problem will be to eliminate by various means those characteristics which cannot be put to use in a better way by suitable engine design.

Since it has been the aim of the builder of the Diesel engine to use left-overs in order to obtain a cheap fuel it has been stated with emphasis by Howard at a previous meeting of the society "that if the Diesel engine is to continue to deliver the full economic advantage that its cycle makes possible, it must not become temperamental as regards fuels," and also "let the fuel be clean, let it meet reasonable specifications but by all means avoid a costly race for heptane numbers." It is added that gasoline and Diesel fuels should not compete for the same components.

Some of the difficulties in regard to ignition delay or timing control to fuels have been overcome according to claims for the newer spark-ignition heavy-oil engine. Fuels with critical ignition ratios of 8:1 to 22:1 have been used successfully in this type of engine. The opinion was expressed that this method offers a practical solution to many of the difficulties faced by the compression-ignition engine.

Treating processes, such as hydrogenation and solvent extraction, were suggested as means of improving Diesel fuels, but the economies of the Diesel may be usually lost by adding expense to the production of the fuel. It is the belief of the author that a change in the mechanical structure of the engine will be simpler than a change in the molecular structure of fuel components. (*National Petroleum News*, vol. 26, no. 25, June 20, 1934, pp. 27–28, *g*)

MACHINE-SHOP PRACTISE

Drawing and Forming Dies for Experimental Work

IN DEVELOPMENT work the problem constantly arises of making special apparatus and samples where drawn parts are used. Drawing dies as they are ordinarily made are too expensive to make where only a very few parts are used, so that jobs of this kind are generally done by hand. The author has succeeded in developing for this kind of work dies which cost little more than it would cost to make the first piece by hand. The author illustrates his method by describing the manufacture of a sample of what now is the Westinghouse TE-4 toaster.

The method cannot be described in detail but essentially is as follows: To draw a piece, the pressure pad is made of celotex with a clearance hole for the punch. The drawplate is made of steel plates $^{3}/_{64}$ in. thick laid one on the other to a thickness equal to the depth of the draw. The punch is made of fine grained hardwood cut to the inside dimensions of the part to be made. The support for the die plate is likewise made of hardwood and the die plate and support are fastened together with wood screws. None of the parts requires hardening or grinding. Substantially the same process is used in the making of the other parts. The author states that he has never found a job where drawn parts, needed on a small scale, which can be made in one operation and which use steel not over $^{1}/_{16}$ in. in thickness, cannot be made in a satisfactory manner on dies so constructed. The author himself has made with such dies rectangular, waffle-iron covers, sandwich-toaster covers, sad-iron covers, which are about as hard a single draw encountered for the depth of the draw, as any article. (J. D. Bolesky, Mansfield Works, Westinghouse Elec. & Mfg. Co., in *American Machinist*, vol. 78, no. 13, June 20, 1934, pp. 440–441, illustrated, *d*)

MACHINE TOOLS

Nitrided Drills

THE author primarily considers the subject of nitrided drills from the point of view of drills to be used on plastics. Here hitherto the only drills that gave complete satisfaction were those made of tungsten carbide, but they were usually not economical for small-lot jobs or were not carried in the small sizes.

To meet this situation high-speed-steel nitrided drills were developed as it was found that the regular high-speed tool can, with very little additional cost and no distortion, be increased in hardness as high as 32 per cent, or to about 1100 Vickers-Brinell, by the simple expedient of nitriding the depth case ranging from 0.006 in. for small sizes of drills to 0.014 in. for the larger sizes.

In this connection the Westinghouse Electric and Manufacturing Company carried out a series of tests reported in detail in the original article with micarta and bronze as the chief working materials. In these tests it was found that high-speed drills stood up extremely well in comparison with other materials and that when they were nitrided they lasted from two to three times longer than the tools made from regular steel, in addition to which the tools were not deformed by heat treatment. The non-carbonization or absence of an outside scale, such as found in case-hardening, is another important factor contributing to the successful operation of the tools.

Establishing a superhard case on the tool from 0.006 in. to 0.015 in. deep per side depends on the number of hours nitrided. The depth of case as mentioned does not mean that the tool increases this much over the original size, but is formed from the outside of the initial size inwardly, leaving a soft core in the center; thus insuring against breakage.

However, there does occur in the diameter or thickness of the tool after nitriding a slight expansion varying from 0.0005 to 0.0015 overall, depending not on the size of the tool but on the number of hours nitrided. This, in turn, represents another major discovery in the nitriding of tools as shown in the case of the drills for the Moldarta job described elsewhere in the original article.

The drills in question were worn undersize approximately 0.0015 in. and rendered useless for the work, but when nitrided, the drills were brought up to the proper size and again placed into service.

One set of drills was nitrided and after wearing each time was renitrided twice in succession with satisfactory results. The growth apparently ended with the third renitriding as no increase was noted in the size of the drills. This reclamation of worn tools on molded materials can be made to pay a generous dividend.

In addition to the drill test, a series of individual tests with taps and cutters was conducted on the same materials with practically the same results. This eventually proved profitable in production jobs requiring the use of small taps of the 6–32, 10–32 variety on molded materials, the taps lasting from four to five times longer.

At the same time supplementary tests were undertaken to learn more of the characteristics of a number of leading nitriding steels on the market. Included in the list were high-speed and cobalt steels.

Samples were solicited from various manufacturers and 20 test tubes were constructed 1-in. on a side. Several cubes were made from the same steel in some cases, but were subjected to different forms of heat treatment before nitriding. The blocks were numbered from 1 to 20, respectively, before nitriding to avoid any errors in later tests.

These data, including the composition and heat treatment of the blocks, are contained in a chart in the original article.

From the experience gained during these observations and tests it has been found that high-speed cutting tools such as drills, taps, reamers, and milling cutters if nitrided are far superior to the same tools not nitrided for cutting resinous materials only, such as micarta, ebony, asbestos, etc., with some exceptions in brass and bronze alloys. (C. E. Greenawalt, Westinghouse Elec. & Mfg. Co., in *Plastic Products*, vol. 10, no. 6, June, 1934, pp. 214–218, several tables, illustrated, *pA*)

PETROLEUM ENGINEERING

Research in the Manufacture of Lubricating Oils

AT THE Eleventh Annual Meeting of the Pennsylvania Grade Crude Oil Association at the Pennsylvania State College, W. B. McCluer, in charge of the laboratory of the college investigating refining methods for lubricants, pointed out that three main tools are available to the refiner, all of which are being studied to determine the sphere of their usefulness to Pennsylvania refiners. These are fractionation, vacuum distillation, and selective solvents. Since these may be, and are, employed in conjunction to improve certain qualities in the oils, it is needful that the exact value of their use be determined, and how they may be used simultaneously to maintain the "quality differential" between Pennsylvania and competitive oils.

He showed that since Pennsylvania lubricants possess natural properties more desirable than those from any other source, that since all the new processes have for their goal the production of oils similar in properties to Pennsylvania oils, or to better those properties from other crudes, the Pennsylvania refiner has an advantage in striving to make better oils, since he starts with the best crude available. All these methods may be applied to Pennsylvania oils as well as to any other, to accentuate those most desirable properties.

For the benefit of the non-technical attendants at the meeting, he likened the production of oils by distillation to a classification of hydrocarbons according to size of molecule. It was necessary also to classify and separate them according to "shape," as he expressed it, or according to the form or structure of the molecule. This could be done best by selective solvents, which separate those molecules of one general "shape" type from those of other types.

By these two methods Mr. McCluer showed that those molecules most desirable for lubricants might be segregated. With a preponderance of molecules which he considered the best for lubricant purposes, found already in Pennsylvania crude, the application of these processes should result in maintaining the quality differential between those and other lubricants, which he referred to as the traditional difference between them. (*National Petroleum News*, vol. 26, no. 25, June 20, 1934, pp. 21, 22, and 24, *g*)

POWER-PLANT ENGINEERING

Vibration of Steam Turbines

NOTWITHSTANDING the large amount of mathematical and experimental work intended to combat it, wheel vibration in steam turbines still ranks today as one of the major nuisances which may afflict the turbine user.

Given a disk of sufficient thickness in proportion to its diameter, it requires neither mathematical nor experimental proof to convince any engineer that it could not possibly suffer from dangerous transverse vibrations of any kind. The thinner it is made the greater the possibility becomes. When it is thin one has to rely upon calculation and experiment to keep clear of the danger point, and by this reliance one tacitly assumes that our theoretical data and our experimental conditions all correspond with the hard facts that will be encountered in practise. Such an assumption must always be questionable. The tightness of the wheel on the turbine shaft, the forces produced by the pressure, flow, or eddying of the steam, and many other factors are all likely to be different from those anticipated. Safety lies in keeping so far on the proper side of the danger limit that unforeseen influences may be neglected. This is indeed the principle of all sound engineering work, in which the provision of large factors of safety, however indefensible academically, has been proved necessary by long experience. Not until all turbine designers have learned this universal lesson may one expect to be free from wheel vibration troubles. It is far more important that a turbine should run properly than that its parts should be proportioned in accordance with the most elegant mathematical theory in the world. Designers are tempted to cut wheel thicknesses to the limit which theory appears to permit, because every increase in thickness means a more heavily loaded shaft and very possibly a longer and more expensive turbine. The larger the turbine, the greater is the inducement to effect a saving in this way, but it is not the way of safety. Efficiency will always demand the expansion of the steam in a large number of stages, and if the wheel-and-diaphragm type of construction is to give satisfaction in machines of considerable size, all liability to vibration must be removed without reducing the number of stages necessary for the highest economy. There is no doubt that this can be done, but to obtain the desired reliability there will have to be a greater liberality in the thickness of wheels than some makers are disposed to allow at present. It is likely, moreover, that blading troubles might also be materially diminished at the same time, for a vibrating wheel can hardly afford a suitable foundation for long blades. (Editorial in *The Engineer*, vol. 158, no. 4103, Aug. 31, 1934, pp. 213, *g*)

Effect of Deficient Draft on Boiler Output

A NUMBER of instances are cited showing the evil effects of flue restriction and other causes of deficient draft on boiler output. In one plant where five boilers were unable to meet the steam demand, a sixth boiler was installed with the result that more coal was consumed and less steam produced. Expert investigation showed that the flue area was sufficient only for three boilers and that there was a solid layer of flue dust 2 ft (figure taken from original article) thick, which must have been damp at times. This dampness was reducing the chimney-gas temperature and therefore the draft. In another instance of defective boiler operation it was found that the bridgewalls at the back of the furnaces had been built so high that there was a space of only 5 in. between the tops of the walls and the furnace crowns. The top portions of the bridges were removed so as to leave a space of about 11 in. and after this alteration there was no further difficulty in meeting the steam demand.

Considerable loss of draft sometimes occurs between the chimney and the furnace chamber owing to complicated baffling arrangements provided with the object of bringing the gases in close contact with the boiler heating surfaces. Through crippling the draft unduly these arrangements may become the cause of both low output and heavy wear and tear. A good draft at the economizer outlet or the chimney base does not necessarily imply that all is well as far as the draft is concerned. Square turns or sudden changes of direction, sharp corners, and dead spaces all tend to impede the free flow of the gases. The longer the flues the greater the resistance to the gas flow, and one authority advises that for flues 500 ft long the effective area should be one and a half times the area given by the ordinary rules, and for flues 1000 ft long, twice as much.

The fireman may be the cause of low or high output. Many years ago a famous firm of boilermakers arranged for five firemen to fire the same boiler, one after the other, the conditions being maintained the same throughout the test. The results of the test showed that whereas the worst fireman obtained an evaporation of only 7.4 lb of water per lb of coal, the best obtained an evaporation of 9 lb, or over 20 per cent more. Other tests have shown that some firemen are capable of getting as much as 25 per cent more out of a boiler than are others, so that a great deal obviously depends upon the firemen.

Occasional supervision of the firemen by an expert engineer-chemist would, in a large number of cases, bring about greatly improved results, for some knowledge of the science of combustion is essential for efficient hand-firing, and this knowledge few men possess. (Edward Ingham in *The Steam Engineer*, vol. 3, no. 12, September, 1934, pp. 505–506, *p*)

Steam-Condenser Operation

THE author deals with some misconceptions as to what happens in a steam condenser. There is, for instance, the idea that since air is more weighty than steam, it will tend to fall through the mixture and that, therefore, the natural position in which to place the air suction is at the bottom of the condenser. In fact, the "draft" of the air pump is so strong as to overcome any such gravitational effect. Full account must be taken of this "draft" in other ways. Directed upward, for instance, it has been suggested that it is even capable of delaying the fall of the condensate from the tubes above, so that a water blanket is formed around them. Any such effect must inevitably have an undesirable resultant upon the rate of heat transmission. The sheer force of the "draft," too, must be taken into account. In one case a lightly constructed tray-like structure installed in the body of a condenser in connection with the reheating of the condensate was literally "blown to pieces" by the violence of the gale.

But it is perhaps in the study of the rate of heat transmission that the greatest difficulty lies. When the interior of a condenser is observed through a glass window, drops may be seen forming upon the tubes, coalescing and falling. Such observations seem, at first sight, effectually to dispose of any theory that a film of moisture resistant to the flow of heat exists upon the outer surface of the tube. Such a film has been assumed to exist by many of those who have experimented upon the subject. But, to look at the matter in another way, it must be remembered that the lower tubes of the condenser are subjected to a continual bombardment of drops falling from those above, and that the rate of this precipitation is anything up to ten times heavier than that accompanying a thunderstorm. Under such conditions it is impossible to believe that condensation can take place by the leisurely formation of drops and their coalescence, whereas it is less difficult to conceive of the existence of a more or less permanent film.

Thus, somewhat picturesquely, the conditions within a condenser in operation may be likened to a rainstorm almost more violent than it is possible to imagine. The "barometer" is unimaginably low; the rain falls at a rate beyond anything we can conceive happening in nature, and the severest of hurricanes blows at more than 200 mph. In such a welter, and with such obstructions as the tube nests and the baffles offer, there must be violent swirls and eddies, although the main wind drives always toward the air suction. Any proposals for the use of queer-shaped tubes, for instance, or for some unusual tube-plate arrangement, or positioning of the air-pump suction, must be considered carefully in the light of these conditions. A demonstration, by means of a few tubes in a small model condenser, of the occurrence of certain phenomena is no more reliable evidence that the same phenomena will occur among the hundreds of tubes in a full-sized plant than would be an artist's conception of the occurrence on a drawing board. (Serial article, second instalment, *The Engineer*, vol. 158, no. 4103, Aug. 31, 1934, pp. 214–215, 1 fig., *d*)

The Rotary Economizer

THIS is a continuation of the article the first part of which was abstracted in MECHANICAL ENGINEERING, October, 1934, pp. 627–628, and deals with the performance of the device.

The author tells of an installation comprising three boilers and having a steam production of from 10 to 17 or 18 tons per hr. As the feedwater-treatment plant was inadequate to deal with this amount, unclean water was used and there soon appeared incrustations in the pipes of the rotary economizer. An investigation showed a uniform division of the deposit in the pipes at the opposite ends of the rotor. In spite of this deposit, which reached a thickness of 2 mm after 2000 working hours, the rotor ran quietly and without vibration. The deposit was loose and easily removable by brushes.

The pipes are secured at the ends by bushes as shown in Fig. 4. During the year the economizer was cleaned three times and each time all of the bushes had to be removed. In spite of this no leakage has been discovered. Fig. 4 shows the packing arrangement and the packing ring *b* made of copper plate and asbestos inlay.

As regards the outer surface it is stated that the boiler attendant use the steam jet to clean it daily and it is found that the cleaning can be done effectively in 3 min. It has been also found that the flue which carries the smoke gases to the economizer remains clean and free of dust deposits which is attributed to the strong induced draft said to be produced by the rotary economizer. In this connection it is said that before the introduction of this apparatus natural draft only was used and after the week-end stoppage and on account of the cooling down of the long smoke-gas flues and chimneys, there was considerable difficulty with the starting of the boilers which had to be heated up many hours before they were required in order to provide sufficient draft to take up the load. The rotary economizer has made it possible to get the boilers into commission in a much shorter time. Moreover, a much finer coal can be used than previously, which could not be done before as there was not sufficient draft to burn the coal economically. The coal costs per ton of steam are given in the original article before and after the installation of the apparatus in the form of curves.

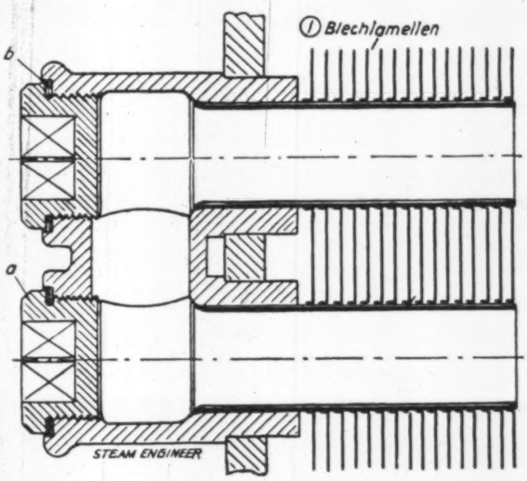

FIG. 4 STOP BUSHES AT THE ENDS OF PIPES IN ROTARY ECONOMIZER

(1 = steel laminae.)

It is worth while mentioning that the plant is so arranged that one can at any time work the boiler plant without the economizer. The amount of space required for the new plant is claimed to be small.

In order to be able to use the rotating economizer with an additional extension of the boiler house, and when going over to higher pressure, arrangements have been made for the whole of the parts to be suitable for working at 35 atm. (Rolf Schruf, in *The Steam Engineer*, vol. 3, no. 11, August, 1934, pp. 480–481, 2 figs., *dp*.) The original German text of this article, published as Proceedings of the Research Laboratories of the Gutehoffnungshütte Co., vol. 2, no. 10, January, 1934, pp. 283–288, with the pertinent illustrations, is available in the United States.

PUMPS

Influence of Suction Head and Characteristics of Fluid on Output of Centrifugal Pumps

THE author points out that pumps which work well on the test stand at the manufacturer's plant do not perform equally well under certain service conditions hitherto unspecified or incompletely specified. He ascribes this to defects in the methods of testing, which, according to his ideas, do not duplicate actual conditions. The usual method of testing centrifugal pumps is to draw the so-called *Q-H-n* curves which give for a predetermined number of revolutions per minute *n* the corresponding delivery outputs *Q* and total manometric delivery head *H* in meters of water. The delivery head on the test stand is usually varied by the partial closing of a valve in the pressure piping of the pump, which is the reason why the *Q-H-n* curves are sometimes called the throttling curves of the pump.

In these tests the suction head remains constant and the usual arrangement for testing is to set the pump directly or nearly directly over the water tank. The water is taken from the tank by suction with a suction head that is at the utmost 2 or 3 m of water and returns it by way of a water meter or weir used for measuring the amount of water delivered.

The author claims that this method of testing is wrong and that for estimating the output capacity of centrifugal pumps it is necessary to consider the suction head as well as the total delivery head. He gives curves which show how the output of pumps falls off with the increase of suction head and claims that this feature of behavior of centriufgal pumps has not been sufficiently appreciated in actual practise. He explains it by stating that the conditions prevailing in connection with the suction of fluids of different kinds and compositions have not yet been sufficiently clarified.

Fig. 5 shows characteristic curves of pumps so drawn that by means of a special scale the maximum permissible suction head for different outputs may be determined. From this it would appear that as the output increases, the power of suction, which means the highest available suction head, falls off; and, vice versa, as the output decreases it becomes possible to use a greater suction head. The suction head of a pump is materially reduced, particularly at higher vacua, by the release of the gases dissolved in the liquid, and at the higher temperatures by the evaporation of the liquid itself. Surface waters from seas and rivers contain air in solution, while ground water may contain both air and other gases, such as carbon dioxide, hydrogen sulphide, and marsh gas.

The author proceeds next to an elaborate discussion of air content in waters of various kinds which cannot be abstracted here because of lack of space. In this connection he gives equations for V_x, which is the increased volume of gases contained in the water corresponding to the reduction of pressure, as well as for V, which is the volume of air liberated for a particular suction head. This is also given in a table in the original article. If a pump unit has an hourly output of Q_h cubic meters, then the volume of air theoretically liberated in the suction tube is

$$V_h = Q_h \times 0.022 \left(\frac{10}{10 - H_{sm}} - 1\right)$$

where H_{sm} is the manometric suction head of the pump in meters of water. From the table referred to it would appear that in the case of the higher suction heads the volume of gas liberated from the water as compared with the amount of water handled (which is practically incompressible) is great enough to affect materially the ouput of the pump.

On the test stand where the suction head is small and the suction piping short, the water containing gases held in solution flows under a vacuum through the suction pipe for only a few seconds which is not enough to permit a liberation of the gases. As a result, in these tests the output of the pump cannot really be established. Furthermore, on the test stand the suction head is artificially increased by valve throttling in the suction piping, this being done for the purpose of determining the suction capacity of a pump. It does not, however, give values good for practical conditions, because, where the suction piping is short, it is only at a quite high vacuum that the magnitude of the suction head appears to be materially affected. The situation is entirely different where longer suction or riser pipes are used.

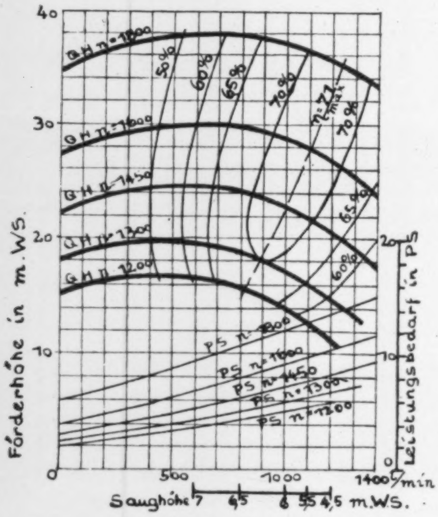

FIG. 5 PUMP-CHARACTERISTIC CURVES

(Abscissas = suction head in meters of water; ordinates = delivery heads in meters of water.)

Where the piping is long, pipe friction has also a material effect on the suction head, and in order to lose as little suction head as possible through friction in the pipe it becomes necessary to keep the velocity of flow of the liquid through the pipe as low as possible, since in the Darcy formula for pipe friction

$$h = \frac{\lambda v^2 100}{2gD}$$

the second power of the velocity v appears. On the other hand, however, low velocity of flow in the suction or riser piping greatly favors the liberation of gases. Furthermore, where such piping must be so dimensioned as to provide for a later enlargement of the pumping plant, the water velocities as first provided for become very low indeed. This also happens when several pumps are connected to a common large suction pipe and only one or a few of the pumps available are in operation. Thus, for example, if a suction pipe is 450 m long and is under given conditions, a velocity of flow $v = 0.3$ m per sec is obtained, it takes the water 1500 sec, or 25 min, to flow from one end of the pipe to the other. Since the particles of water up to the pump connection are gradually exposed to higher and higher suctions, the major part of the air or gases held in solution in the water is liberated as a result of a comparatively long exposure to vacuum. No reliable figures are available as to how great a percentage of gas content and how long a time are necessary to liberate gases held in solution in the water under a vacuum of a given magnitude. In general it is known, however, that air dissolved in water liberates slower than carbon dioxide.

The output capacity of a pumping plant is more or less unfavorably affected by the liberation of gases. The pump suction is less effective, and if the suction piping has not been laid out skilfully, the pump frequently fails in suction. Furthermore, if the pumping plant is not under constant supervision, as is usually the case where automatic connections are provided, this may lead to a greater frequency of outages.

The centrifugal-pump design shown in Fig. 6, has the disadvantage of having the suction chamber on the entrance side to the first blade wheel where a comparatively large amount of air can accumulate. This reduces the suction capacity. In fact, if the liquid pumped contains much air or gas, so-called vapor lock may appear and cause trouble. Pump designs, such as shown in Fig. 7, containing no suction chamber, are not quite so sensitive to this trouble, as gases liberated from the liquid in the suction piping cannot accumulate in front of the first blade wheel. If the amount of gas liberated is not excessively great, it is carried with the liquid, and outages from vapor lock do not occur. The air which is pushed on by the blade wheel, however, always has a tendency to accumulate in the upper part of the pump housing. In a single-stage pump this may be carried off through a passage provided for this purpose from the upper part of the pump housing to the pressure connection of the pump, and if such a passage is not provided in the original construction it can be easily installed subsequently by means of a thin-walled wrought-iron tube.

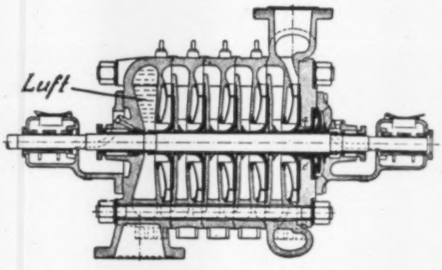

FIG. 6 IMPROPER DESIGN OF A CENTRIFUGAL PUMP PERMITTING FLOODING WITH GAS AND AIR

Of course, the pump designer must beware that no air gets into it from the outside. This applies particularly to stuffing boxes (usually a weak point in centrifugal-pump design) in pumps for special purposes, such as pumps handling hot water, lyes, etc. Stuffing-box design is more fully considered in the original article but cannot be abstracted here because of lack of space.

As the suction head and hence the output capacity of a pump depend on the atmospheric pressure, the altitude of the location of a pumping plant must be taken into consideration in judging of its future performance. The maximum theoretical suction head of about 10 m of water, for water or liquids having the same density $y = 1$, can be obtained only for a barometer reading of 760 mm of mercury, which is the condition prevailing at sea level. In the case of liquids having other densities, the theoretical suction head varies in proportion to $1/y$, as shown in a table in the original article for a number of liquids from alcohol to sulphuric acid. For benzol, for example, with its specific weight 0.88, the maximum theoretical suction head is $10/0.88 = 11.4$ m. This specific head can never be attained in practise because of the large evaporating capacity of the liquid. Where liquids that are easily vaporized, such as gasoline and benzol, are to be used, the manometric suction head in excess of 4 m should not be assumed. This is further illustrated by a curve in the original article. In general, the author recommends keeping the manometric suction head as low as possible and to do this it is necessary to take several factors into consideration. He offers the following formula

$$H_{sm} = h_g + h_r + h_v + v^2/2g$$

where H_{sm} is the total manometric suction head in meters of water; h_g is the geodetic suction head, that is, the vertical distance of the center line of the pump to the level of the liquid; h_r the frictional resistance of the pipe in the suction piping in meters of water; h_v the valve resistance in meters of water; and $v^2/2g$ the head of acceleration in the narrowest cross-section of the suction pipe or the valve in meters of water.

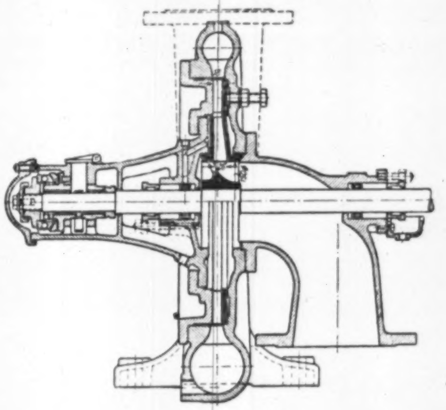

FIG. 7 CENTRIFUGAL PUMP WITHOUT SUCTION CHAMBER

Except in special instances, the geodetic suction head always constitutes the major part of the total manometric suction head. Hence, the geodetic suction head must be maintained as small as possible, having regard, where necessary, to future developments in the plant. Of course, all the other resistances, such as pipe friction and valve resistances, must be kept as small as possible. This is particularly important in the case of pumping plant having a large output with a comparatively small delivery head.

In designing the piping which leads the liquid to the pumps, it is particularly necessary to see to it that nowhere can air and gas accumulate in it, which means that dead angles should be avoided. The riser and suction piping must therefore be led to the collector well or suction joint of the pump by a gradual rise. Since the riser piping in the collector well takes a vertical turn downward, it is necessary to provide for the removal of the gases that might accumulate at the highest point of the riser tube, as without this, the riser will not work continuously. Fig. 10 of the original article shows such a riser deaerating unit (patented by Francke Works Co., Bremen), which, by means of an electrically driven vacuum pump, automatically cut in and out, removes the air liberated in the riser pipe or in the vacuum vessel. In this machine the water level in the vacuum vessel operates an electric switch which admits current to the vacuum-pump motor, this being done by means of a special tipping vessel connected with the various pipes. If so much gas has accumulated in the vacuum vessel that the water level therein has fallen to the lower edge of the tipping vessel, the latter empties and is raised by a counterweight which closes an electric switch and starts the vacuum pump. When the gases have been removed the vacuum vessel again fills with water so that the level of water therein rises, but it is only when the water level has reached its upper value that water can again run into the tipping vessel. The latter then moves downward, opens the electric switch, and stops the vacuum pump.

The author discusses next the case of a large pumping plant, particularly one with the independent operation of several pumps where gross defects can be encountered in the arrangement of the suction piping. Fig. 8 shows an instance of an improper arrangement of suction piping servicing several pumps at once. Because of the fact that the mass the gases separated from the liquid is proportional to the amount of water taken in by suction when all three pumps are in operation, pump I gets practically all the gas liberated, with the result that it operates irregularly and frequently ceases operating entirely. If only pump III is running, the gases separated in the incoming suction piping go first to pumps I and II and collect in the suction piping. It is only then that the gases flow to pump III. Now if pump I or II is independently cut in, it will not operate because the space is filled with gas. This may result in overheating and burning out of the stuffing boxes.

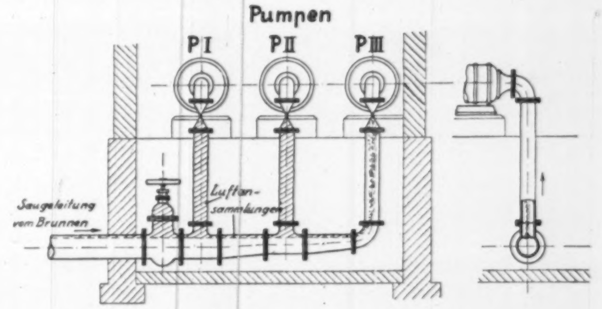

FIG. 8 IMPROPER ARRANGEMENT OF SUCTION PIPING SERVICING SEVERAL PUMPS

(*Saugeleitung vom Brunnen* = suction pipe from well; *Luftansammlungen* = collection of air.)

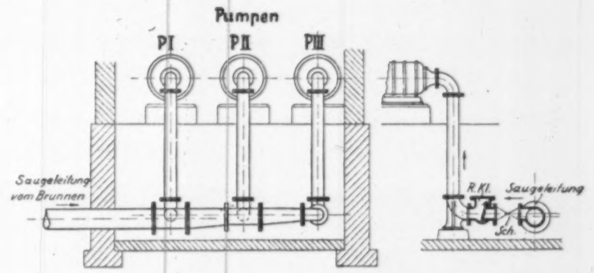

FIG. 9 PROPER ARRANGEMENT OF SUCTION PIPING SERVICING SEVERAL PUMPS

(*Saugeleitung* = suction pipe; *Saugeleitung vom Brunnen* = suction pipe from well.)

To insure reliable operation of the pumps, it is necessary to arrange the suction piping as shown in Fig. 9. The branching off of the individual pump suction pipes from the main suction pipe by means of eccentric T-pieces and the arrangements of the return valves at the beginning of these suction pipes prevents gases from settling in the pumps and connecting pipes which are not in operation. By this means the gas flows uniformly to the pump which is in operation, assuming, however, that the amount of gas liberated is not so great that the pump in operation is incapable of handling it. (Emil Lügger in *Fordertechnik und Frachtverkehr*, vol. 27, no. 56, Mar. 9, 1934, pp. 51–56, 13 figs. *pA*)

REFRIGERATION

"Dry-Ice" Cooling Device for Steamships

THIS device was designed by Ralph V. Grayson, consulting engineer, of Atlanta, Ga., and involves cooling with solid carbon dioxide, "dry ice." The system constitutes a cooling unit made of telescoping tanks of metal, a damper control mechanism, thermal unit, glandless piston valve, and various accessories. Three tanks are embodied in one single unit. The outer and intermediate shells constitute the high-vacuum insulating space. The intermediate and inner shells provide a continuous-air-circulating space which is in communication with the area to be cooled by means of a damper and valve mechanism. The system may be operated with air or with an auxiliary refrigerant in the air chamber.

The damper mechanism where air cooling is used constitutes a multiple damper actuated by a thermal unit which expands and contracts with the temperature differential. The action of the thermal element operates a glandless piston valve opening and closing the dampers as refrigeration is demanded. In the case of an auxiliary refrigerant, the same mechanism opens and closes the refrigerant valve in lieu of dampers, thus permitting the passage of the refrigerant as demand is made.

An automatic pressure-control valve, which opens at 50 lb per sq in. and closes at 20 lb per sq in., governs the turbo-blower operation, thus effecting an intermittent cycle of forced circulation. The turbine is of standard design with special nozzles which effect efficient operation and maximum speed during the operating cycle.

In operation solid carbon dioxide is placed in the inner tank and sealed therein. The sublimation of the "dry ice" in the inner tank creates a pressure which is used to operate a turbo-blower through the medium of a conduit and an automatic valve. This turbo-blower is directly connected with the hold by means of a conduit at the top and one at the bottom of the hold. The warmer air is taken from the top of the hold, passed down through a mixing chamber with the refrigerated air, and thence to the hold through a conduit which is placed well below the surface or dunnage in the bottom of the hold. This circulation is effected intermittently and is carried on, whether or not refrigeration is demanded at the particular time of the operating cycle. When refrigerated air is not supplied to the mixing chamber, the circulation is through the conduit system, thus insuring temperatures within 2 deg at the top and the bottom of the hold. (*Ice and Refrigeration*, vol. 87, no. 2, August, 1934, pp. 77–78, illustrated, *d*)

SPECIAL MACHINERY

A Three-Drum Scraping System

A SCRAPER installation is often the most convenient and economical way of handling coal, rock, and similar material in bulk storage, or for excavating in certain kinds of earth. It is, however, what might be called a "straight-line" process, and the pulley remote from the winch has to be moved by suitable means in order to alter the line of travel of the scraper.

A way of controlling this motion has been devised by Holman Bros., Ltd., of Camborne, England, who have produced what they call a three-drum scraping system. With this the position of the tail sheave is controlled by the operator of the winch, the time taken to change the line of pull being thereby reduced and without involving extra labor.

A view of the winch showing the disposition of the drums is given in the original article, and in Fig. 10 the principle of the system is illustrated. In the latter, the tail sheave, ropes, and scraper are shown in two positions, indicated by full and dotted lines. It will be seen that two ropes are used for hauling the scraper backward and forward, and the third, after passing over a fairlead at the left of the diagram, passes over a sheave on the tail block, thence to the fairlead at the right of the diagram, and finally to a fast end on the tail block.

The first pass of the third rope over the tail-block sheave holds the block against the hauling pull, and the pull on the fast end resists an opposite reaction due to the angularity of the hauling rope where it passes through the block.

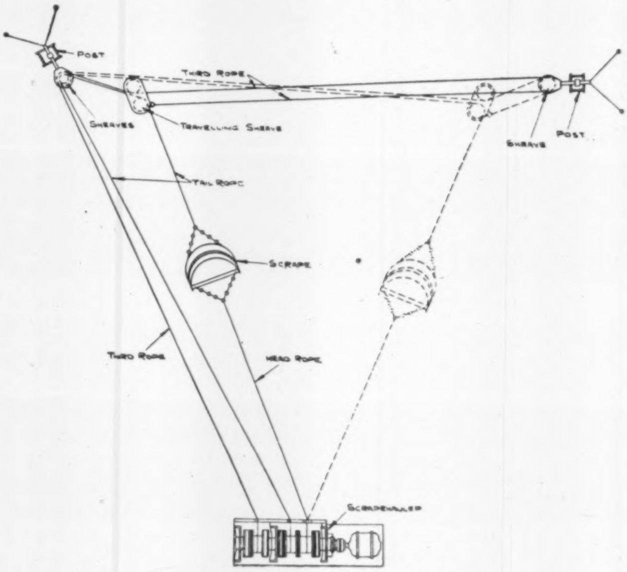

FIG. 10 DIAGRAM OF THREE-DRUM SCRAPING SYSTEM SHOWING SHEAVE IN EXTREME POSITION

The tail block can therefore be placed anywhere on the dump by suitable regulation of the three ropes. For instance, to change the scraping line from the position shown by the full lines in Fig. 10 to that shown by the dotted lines, it is only necessary to release the brake which holds the third rope stationary and engage the clutch to wind in the rope. To reverse the positions, the tail rope is wound in while both the clutch and brake of the third rope are disengaged. (*Mechanical World*, vol. 95, no. 2473, May 25, 1934, pp. 498–499, 3 figs., *d*)

SPRINGS

Winding Silica Springs

THESE springs are used in balances for handling extremely small weights when great accuracy is required. In the past helical springs of silica drawn to the fineness of thread have been made by hand. The operation had been difficult and tedious and the springs have had irregular shapes and properties far from uniform. A machine has now been developed which automatically winds the silica fiber in a helix.

One of the peculiar features about silica springs is that the temperature coefficient of rigidity is negative so that a loaded spring contracts when heated. This contraction per degree centigrade is about $^1/_{100}$ of 1 per cent of the elongation due to load. (H. W. Weinhart, *Bell Laboratories Record*, vol. 12, no. 10, June, 1934, pp. 316–318, 3 figs., *d*)

STEAM ENGINEERING

Steam Raising With Lancashire Boilers

THE paper deals with an installation at the Raglan collieries in South Wales, where a coal-washing plant was installed to meet modern market requirements, and because of this considerable amounts of fines accumulated. Attempts were made to burn these products mixed with "through" coal, but it was found that considerable alteration and expenditure would have to be incurred to bring about efficiency and lower fuel cost, if a full use of this supply of low-grade fuels was to be made and future power requirements dealt with properly. On the other hand, the high-volatile dry fines presented an admirable opportunity for pulverized firing if some of the difficulties then associated with such firing in Lancashire boilers could be overcome.

When two additional boilers were added to the plant an order for pulverized-fuel equipment for these boilers was placed with Alfred Herbert of Coventry. This is the only plant in South Wales equipped with Lancashire boilers. The burners are of the Turba-Dispersive type and are supplied with secondary air under pressure. The fire flues are bricked for a short distance for the purpose of protection and combustion stabilization. The pulverized fuel is distributed to the four burners by branch pipes provided with regulating valves controlled and operated from one fan placed above the firing platform.

In order to allow for long periods of operation dust blowers are evenly spaced in the fire flues, flame bed, and side flues. They are operated at regular intervals and in sequence by manifold valves, and the dust is carried along the course of the flue gases to discharge into a water-spray collecting chamber. Suitable main-flue dampers are used to by-pass gases to the chamber during this operation, and steaming is uninterrupted. The first 15 ft of the fire flues are raked out by hand at regular intervals, and approximately 50 per cent of the ash in a light, cindery, nodulized form is extracted in this manner. Similar dust-blowing arrangements are at present being increasingly used on ordinary Lancashire boiler plants for fire-cleaning purposes.

This is a case where the plant was laid out to deal with a particular cheap fuel difficult of commercial disposal and unattractive for other methods of firing. The closeness with which it may be kept at a predetermined figure of efficiency is especially valuable. Wet slurries were still, however, being inefficiently fired in the other boilers, and "through" coal was not completely and regularly excluded from the boiler house; a further field for increased efficiency and cost production therefore awaited a satisfactory solution.

The economizers are small, and very little effective use was being made of the available exhaust steam. It was therefore felt that the exhaust steam could be used to a much greater extent to heat feedwater, coupled with hot-water storage, and that this would provide such an increase of temperature at the economizer inlet that its performance would be vastly improved, and increased capacity definitely avoided. At the same time this would leave available heat in the waste gases for further utilization.

The author had received information as to the remarkable economies made in steam production at the Royal Arsenal, Woolwich, partly by the harnessing of waste flue gases. Following a close investigation, it was arranged that an exhaustive test should be carried out on the preheated-air Lancashire boilers at the research boiler house at the Arsenal. About 40 tons of the fuel was forwarded to Woolwich, and valuable independent tests and reports were made; the results were highly satisfactory and important possibilities were thus opened up. Eventually a contract was placed for a similar air preheater and auxiliaries with the Carrier Engineering Co. (Vernon O. Jones, *The Colliery Guardian*, vol. 148, no. 3827, May 4, 1934, pp. 815–819, 6 figs., *d*)

TESTING AND MEASUREMENTS

Non-Destructive Testing of Welds

THE Operating Committee of the Board of Experts on Welding Engineering connected with the Verein deutscher Ingenieure and Board 760 of the German Society for Technical Application of X-Rays, in turn connected with the Association for Testing of Engineering Material, have issued a memorandum dealing with various processes for the non-destructive testing of welds. It is stated at the beginning of the report that the extent of applicability of the various processes is presented in the report as being of present validity only, as there is not enough information to determine the sensitiveness of the various processes referred to in the report and the degree to which the results of the tests coincide with performance in actual practise.

It is stated that X-ray examination can be applied to a number of types of seams of any thickness that can be encountered in ordinary practise, and, if properly employed, gives a reliable indication of the presence of gas and slag inclusions, in general, also indicating the presence of cracks and lack of continuity. The location of the difficulties can be effected approximately by means of stereophotographs. As regards the disadvantages of the process, it is stated that the application of the process involves the danger of injury to operators through contacts with parts carrying high voltages, or through the action of the rays themselves. Both of these sources of danger can, however, be eliminated more or less entirely by taking proper precautions.

The gamma-ray photography is substantially the same as the X-ray photography, but with thin and medium thick walls the ability to locate defects is materially lower than it is in X-ray photography. It is recommended as a substitute for X-ray photography where the latter is not applicable.

The application of the process from the point of view of possibility of injury to the health of the workmen by rays is even greater than with the X-ray process. The capacity to indicate defects in thin walls is small as compared with other processes. The duration of the illumination has to be much longer than in the X-ray process and the gamma-ray process is less suitable than the X-ray process for testing butt welds or overlapping press welds.

The iron-filings process is applicable only to paramagnetic materials, and its advantages and defects are stated in detail in the original article. The same applies to the magneto-acoustic process, the application of which is cheap and convenient. This process, however, is possible only with paramagnetic materials and depends largely on the skill of the operator. The process does not provide any permanent record. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 78, no. 32, Aug. 11, 1934, p. 965, *p*)

BOOK REVIEWS

Newton's Principia

Newton's Principia: Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World, translated into English by Andrew Motte in 1729. The translation revised, and supplied with an historical and explanatory appendix, by Florian Cajori, late Professor of the History of Mathematics, Emeritus, in the University of California. University of California Press, Berkeley, Calif., 1934. Half leather, 7 by 10 in., 680 pp., with Newton's diagrams redrawn from the Motte translation and with frontispiece portrait, $10.

Reviewed by Wm. F. Durand[1]

THE mathematical world has for many years been familiar with the special interests of the late Florian Cajori in the historical aspects of the broad domain of the mathematical sciences. Those nearer to him knew also that as one of his most cherished undertakings in this field, he had long considered the project of a revision of Newton's "Principia" with annotations, both critical and historical, and with a rendering of the obscure mathematical phraseology of Newton's day into more modern form, thus furnishing an easier reading for students of the present day. This project he was able to carry out fully, having completed the work, with the exception of a preface of his own, shortly before his death in August, 1930. The revision is based on Motte's translation, and preserves the characteristic Newtonian style as well as the general character and style of Motte's translation, making only such changes as seemed needful for the major purpose—viz., that of presenting the "Principia" in language which should conform mathematically to the established usages of the present day rather than to those of Motte's and Newton's times.

Thus "reciprocally in the subduplicate ratio of" becomes "inversely as the square root of;" "subsesquiplicate ratio" becomes "two-thirds power of the ratio;" "quantity of motion" becomes "momentum;" with many other like changes, resulting in a "Principia" cast in modern terminology which the student of today can read without frequent questioning as to the exact meaning in Newton's mind.

The book opens with a brief note by Prof. R. T. Crawford (Professor of Astronomy at the University of California) to whom, after the death of Professor Cajori, was entrusted the task of finally editing the work and of seeing it through the press. Then follow a facsimile of the title page of the first edition of the "Principia," the ode dedicated to Newton by Edmund Halley, Newton's preface to the first edition and to the second edition, Cote's preface to the second edition, and Newton's preface to the third edition. Then follows the "Principia" proper under the well-known divisions of Book 1, the Motion of Bodies, in 14 sections; Book 2, The Motion of Bodies (in Resisting Mediums) in 9 sections; Book 3, The System of the World (in Mathematical Treatment) under four heads; and finally, The System of the World (in Non-Mathematical Treatment).

Then follow Professor Cajori's critical and historical notes, 59 in number, written in his well-known lucid and convincing style. These notes deal with all phases of the subjects occurring in the "Principia" and are accompanied by copious references to original sources. No adequate idea, in a review, can be given of the character and scope of these notes. A few only may be mentioned. Thus No. 11 gives an illuminating and interesting account of the growth of the modern term "mass" as representing Newton's "quantity of matter." No. 13 deals with absolute motion and absolute time and thus leads directly to the modern concepts brought in by Einstein, Minkowski, and the modern relativistic school of thought. No. 26 deals with the velocity of light, No. 28 with motion in a medium where the resistance varies as the velocity, and No. 33 with the long and famous dispute between Newton and Leibnitz regarding the invention of the calculus.

It is not too much to say that these notes throw a flood of light on the "Principia" itself, clearing up obscure passages, connecting the past with the present, and enabling the modern reader to reap immediately the benefit of the long and patient studies of Cajori in the better elucidation of this great work and in bridging over the gap in mode of thought and in terminology between Newton's time and our own.

Motte's translation of Newton's "Principia" can hardly be called a popular book of reference for the modern mathematician or scientist It is not too much to say, however, that Cajori's revision with his notes furnishes an edition of this great work which, though it may not become popular reading, will at least put Newton's thought into language readily understood by the modern reader and will give him, through the critical and historical notes, priceless collateral and background information to the great enhancement of his understanding and appreciation of this great work and of the life and times in which it was written.

The book is a fine specimen of the printer's art—680 pages with Newton's diagrams and illustrations carefully redrawn and printed.

This work forms a fitting close to the activity of Professor Cajori and will always stand as a monument to his industry, historical acumen, critical genius, and capacity for lucid and convincing exposition. The editor is to be congratulated on having had the opportunity of placing the finishing touches on Professor Cajori's work, and the University of California Press is to be commended for this service to the present age of mathematicians, scientists, and engineers in bringing out this work and in thus enabling present-day readers to enjoy the fruits of Professor Cajori's labors and to read, with understanding and in modern terminology, this great historical source of present-day science and engineering.

Principles of Self Shifting Gear Transmissions for Automobiles, by C. H. Powell. Edwards Brothers, Ann Arbor, Mich., 1934. Paper, 5 × 8 in., 66 pp., diagrams, charts, tables, $1.50. This little volume is intended as a guide in the development and design of automatic transmissions. The author first analyzes the requirements and then discusses the choice of gear ratios, driving situations and the effect of reduced throttle, the arrangement of in-mesh transmissions, control, and governors. The book is based upon research work at the University of Michigan.

Der Zündvorgang in Gasgemischen. By G. Jahn. R. Oldenbourg, Munich and Berlin, 1934. Paper, 7 × 10 in., 69 pp., charts, tables, 6 rm. This work describes a series of tests of the Nusselt equation for the velocity of ignition in gases, undertaken to determine the limits of its applicability. The effects of various factors were determined, and a general form for the equation derived.

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A.S.M.E. Program
for 1934 ANNUAL MEETING

New York, N. Y., December 3-7

(Unless otherwise stated all events will be held at the Engineering Societies Building, 29 West 39th Street, New York, N. Y.)

MONDAY, DECEMBER 3

10:00 a.m. Council Meeting **Room 502**

(Members of Local Sections, Professional Divisions, Standing and Technical Committees Are Invited to Attend)

2:00 p.m. Business Meeting **Auditorium**

8:00 p.m. Council Meeting *(continued)* **Room 502**

TUESDAY MORNING, DECEMBER 4

9:30 a.m. Welding Vs. Casting Auditorium

Auspices Machine Shop Practice Division

Presiding Officer: R. E. W. Harrison, Mem. A.S.M.E., Chief, Machinery and Agricultural Implement Division, Department of Commerce, Washington, D. C.

Recorder: H. V. Harding, Mem. A.S.M.E., Peter Clark Inc., New York, N. Y.

1—Welding

By Everett Chapman, Mem. A.S.M.E., Lukenweld Inc., Coatesville, Pa.

2—Users' Viewpoint

By Sol Einstein, Mem. A.S.M.E., Cincinnati Grinders Inc., Cincinnati, Ohio

9:30 a.m. Heat Transfer—I Room 501

Auspices of Process Division, Cooperating With A.S.R.E. and A.S.H.&V.E.

Presiding Officer: Kenneth B. Millett, Griscom Russell Co., New York, N. Y.

Recorder: John H. Sengstaken, Assoc-Mem. A.S.M.E., Superheater Co., New York, N. Y.; Chairman, Heat-Transfer Committee.

1—Automobile Cooling

By L. P. Saunders, Chief Engineer, Harrison Radiator Corporation, Lockport, N. Y.

2—Heat Transfer in the Dairy Industry

By Harvey Feldmeier, Mem. A.S.M.E., Cherry-Burrell Corporation, Little Falls, N. Y.

3—Heat-Exchangers in the Dairy Industry

By R. L. Berry, University of California, Davis, Calif.

9:30 a.m. Railroad—I Room 502

Auspices of Railroad Division

Presiding Officer: C. B. Peck, Assoc-Mem. A.S.M.E., Editor, *Railway Mechanical Engineer*, New York, N. Y.; Chairman, A.S.M.E. Standing Committee on Professional Divisions; Chairman, Railroad Division.

Recorder: John Maziaka, Brooklyn Union Gas Company, Brooklyn N. Y.

1—Tractive Effort of Steam Locomotives (Locomotive Ratios—II)

By A. Lipetz, Mem. A.S.M.E., American Locomotive Co., Schenectady, N. Y.

2—Locomotive Tractive Effort in Relation to Speed and Steam Supply

By E. J. Young and C. P. Pei, Mem. A.S.M.E., Champaign, Ill.

9:30 a.m. Bearing Analysis Room 1501

Auspices of Applied Mechanics Division

Presiding Officer: G. B. Karelitz, Mem. A.S.M.E., Professor of Mechanical Engineering, Columbia University, New York, N. Y.

Recorder: Harvey S. Konheim, Assoc-Mem. A.S.M.E., Consulting Engineer, New York, N. Y.

1—Effects of Side Leakage in 120-Degree Centrally Supported Journal Bearings*

By Sidney J. Needs, Mem. A.S.M.E., Kingsbury Machinery Works, Inc., Philadelphia, Pa.

2—Performance of Large Journal Bearings

By R. Beaudry and L. M. Tichvinsky, Research Laboratory, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

9:30 a.m. Apprenticeship Training Room 1101

Auspices Committee on Education and Training in Industry

Presiding Officer: C. J. Freund, Mem. A.S.M.E., Dean, College of Engineering, University of Detroit, Detroit, Mich.

Recorder: Frank Cushman, Mem. A.S.M.E., Chief of Industrial Educational Service, Washington, D. C.

1—An Opportunity Analysis of College-Grade Occupations Compared With Those of the Professional Engineer

By Marion B. Richardson, Assoc-Mem. A.S.M.E., Ahrens & Richardson, New York, N. Y.; Secretary, A.S.M.E. Railroad Division.

2—The Apprentice School in Industrial Education

By Don F. Smith, General Superintendent, General Electric Company, Erie Works, Erie, Pa.

3—Discussion of Industrial Training Under NRA

** Papers marked with asterisk are being published either in the October or November, 1934, issues of A.S.M.E. Transactions*

9:30 a.m. Fans Room 903

Auspices Power Test Codes Subcommittee

Presiding Officer: W. H. Carrier, Mem. A.S.M.E., Carrier Engineering Corporation, Newark, N. J.

Recorder: A. T. Brown, Public Service Corporation of New Jersey, Newark, N. J.

1—Air Flow in Fan Discharge Ducts*

By Lionel S. Marks, Mem. A.S.M.E., Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

2—Pulsating Air Flow*

By Neil P. Bailey, Assoc-Mem. A.S.M.E., Iowa State College, Ames, Iowa

3—Progress Report on Fan Research at Lehigh University

By W. E. Somers, Jun. A.S.M.E., Lehigh University, Bethlehem, Pa.

4—Status of Test Code for Fans

By M. C. Stuart, Mem. A.S.M.E., Lehigh University, Bethlehem, Pa.; Chairman, Power Test Codes Committee No. 10.

5—The Intake Orifice and a Proposed Method for Testing Exhaust Fans

By N. C. Ebaugh, Mem. A.S.M.E., and R. Whitfield, Georgia School of Technology, Atlanta, Ga.

TUESDAY AFTERNOON, DECEMBER 4

2:00 p.m. Domestic Heating Auditorium

Auspices of Fuels Division

Presiding Officer: R. A. Sherman, Mem. A.S.M.E., Battelle Memorial Institute, Columbus, Ohio.

Recorder: M. D. Engle, Mem. A.S.M.E., Edison Electric Illuminating Company, Boston, Mass.

1—Experience With Application of Central-Station Practise to Domestic Heating

By M. K. Drewry, Mem. A.S.M.E., Assistant Chief Engineer of Power Plants, Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

2—The Use of Oil in Domestic Heating

By L. E. Seeley, Mem. A.S.M.E., Professor of Mechanical Engineering, Yale University, New Haven, Conn.

3—The Use of Gas in Domestic Heating

By R. B. Leckie, Professor of Gas Engineering, Purdue University, Lafayette, Indiana

2:00 p.m. Safety Room 501

Auspices of A.S.M.E. Safety Committee

Presiding Officer: Wesley M. Graff, Mem. A.S.M.E., Director of Safety Engineering, National Bureau of Casualty & Surety Underwriters, New York, N. Y.

Recorder: J. M. Brown, Brooklyn Edison Company, Brooklyn, N. Y.

1—The Problems of Occupational Diseases in Industry

By F. Robertson Jones, General Manager, Association of Casualty and Surety Executives, New York, N. Y.

2—The Administration of Occupational-Disease Control

By Dr. Albert S. Gray, Director, Bureau of Occupational Diseases, Department of Health, Hartford, Conn

3—Origin and Sources of Toxic Dust From Various Industries

By R. F. Stratton, The Travelers Insurance Company, Hartford, Conn.

4—Dust Control, Present and Future Design

By Theodore Hatch, Instructor of Sanitary Engineering, Harvard School of Public Health, Cambridge, Mass.

5—Engineering Methods of Prevention of Occupational Diseases Other Than Caused by Toxic Dust

2:00 p.m. Railroad—II Room 502

Auspices of Railroad Division

Presiding Officer: C. E. Barba, Mem. A.S.M.E., Formerly Chief, Motor Bureau, Boston & Maine Railroad.

Recorder: Marion B. Richardson, Assoc-Mem. A.S.M.E., Ahrens & Richardson, New York, N. Y.; Secretary, A.S.M.E. Railroad Division.

1—Draft-Gear Action in Long Trains

By O. R. Wikander, Mechanical Engineer, Ring Spring Department, Edgewater Steel Company, Pittsburgh, Pa.

2—Alloy Steel and Its Application to Car Equipment

By J. A. Ralston, Manager, Railroad Research Bureau of the Subsidiary Manufacturing Companies of the U. S. Steel Corporation, and A. F. Steubing, Railroad Mechanical Engineer, Commercial Office, U. S. Steel Corporation, New York, N. Y.

3—Progress Report in Railroad Engineering

By G. W. Rink, Mem. A.S.M.E., Assistant Superintendent of Motive Power, Central Railroad of New Jersey, Jersey City, N. J.

2:00 p.m. Bearing Practise Room 1501

Auspices of Machine Shop Practice Division; Lubrication Engineering Committee Cooperating

Presiding Officer: James A. Hall, Mem. A.S.M.E., Professor of Mechanical Engineering, Brown University, Providence, R. I.

Recorder: E. M. May, Assoc-Mem. A.S.M.E., Engineer, S. F. Bowser & Co., New York, N. Y.

1—Current Practise in Pressures, Speeds, Clearances, and Lubrication of Oil-Film Bearings

By H. A. S. Howarth, Mem. A.S.M.E., Kingsbury Machine Works, Philadelphia, Pa.

Discussions will be contributed by those assisting in the survey.

2:00 p.m. Materials Room 903

Auspices of Applied Mechanics Division

Presiding Officer: John M. Lessells, Mem. A.S.M.E., Consulting Engineer, Philadelphia, Pa.

Recorder: I. Gutmann, Engineering Index, New York, N. Y.

1—Stress Analysis of Failures in Machine Parts

By F. A. Mickle and Dr. F. L. Everett, Jun. A.S.M.E., University of Michigan, Ann Arbor, Mich.

2—The Fatigue of Shafts at Fitted Members

By R. E. Peterson, Assoc-Mem. A.S.M.E., and A. M. Wahl, Assoc-Mem. A.S.M.E., East Pittsburgh, Pa.

3—Pitting of Metallic Surfaces Due to Rolling Contact

By Stewart Way, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

4—Strength and Design of Covers, and Flanges for Vessel Openings

By T. McLean Jasper, Mem. A.S.M.E., H. Gregerson, and A. M. Zoellner, A. O. Smith Corporation, Milwaukee, Wis.

2:00 p.m. Heat Transfer—II Room 603

Auspices of Process Division; A.S.R.E. and A.S.H. & V.E. Cooperating

Presiding Officer: C. E. LUCKE, Mem. A.S.M.E., Professor of Mechanical Engineering, Columbia University, New York, N. Y.

Recorder: J. H. SENGSTAKEN, Assoc-Mem. A.S.M.E., Superheater Co., New York, N. Y.

1—Discussion of the Status of the Heat Transfer Between Liquid and Gas in Contact

By A. WEISSELBERG, Jun. A.S.M.E., Consulting Engineer, Jersey City, N. J.

2—Investigation of Heat-Transfer Rates on External Surface of Baffled Banks

By R. A. BOWMAN, Jun. A.S.M.E., Westinghouse Electric & Manufacturing Co., Philadelphia, Pa.

3—Report on Research in Cotton-Seed Oil Processing

By W. R. WOOLRICH, Mem. A.S.M.E., Chief, Industrial Division, Tennessee Valley Authority, Knoxville, Tenn.
(Contributed by A.S.M.E. Research Committee on Cotton-Seed Oil Processing)

2:00 p.m. Engineering History Room 1101

Presiding Officer: JOSEPH W. ROE, Mem. A.S.M.E., Professor of Industrial Engineering, New York University, New York, N. Y.

1—Movement for the Study of Technical History

By I. N. LIPHSHITZ, New York, N. Y.

4:30 p.m. Thurston Lecture Auditorium

TUESDAY EVENING, DECEMBER 4

8:30 p.m. Presidents' Night Auditorium and Fifth Floor

WEDNESDAY MORNING, DECEMBER 5

9:30 a.m. Industrial Power Auditorium

Auspices of Power Division

Presiding Officer: A. G. CHRISTIE, Mem. A.S.M.E., Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md.

Recorder: J. M. BRENTLINGER, Mem. A.S.M.E., DuPont Company, Wilmington, Del.

1—Flow Distribution in Forced-Circulation Once-Through Steam Generators*

By H. L. SOLBERG, Mem. A.S.M.E., G. A. HAWKINS, Jun. A.S.M.E., and A. A. POTTER, Past-President, A.S.M.E., Purdue University, Lafayette, Indiana.

2—Influence of Bends or Obstructions at the Fan Discharge Outlet on the Performance of Centrifugal Fans*

By L. S. MARKS, Mem. A.S.M.E., J. H. RAUB, Jun. A.S.M.E., and H. R. PRATT, Harvard University, Cambridge, Mass.

9:30 a.m. Budgetary Control Room 501

Auspices of Management Division

Presiding Officer: H. V. COES, Mem. A.S.M.E., Ford, Bacon & Davis, New York, N. Y.

Recorder: W. H. KUSHNICK, Jun. A.S.M.E., Anchor Cap & Closure Corporation, Long Island City, New York; Secretary, A.S.M.E. Management Division.

1—Fundamentals of Budgeting

By HAROLD A. HOPF, Mem. A.S.M.E., H. A. Hopf & Co., New York, N. Y.

2—Budgeting an Industrial Enterprise*

By WALTER RAUTENSTRAUCH, Mem. A.S.M.E., Professor of Industrial Engineering, Columbia University, New York, N. Y.

9:30 a.m. Broaching Room 502

Auspices of Machine Shop Practice Division

Presiding Officer: BENJAMIN P. GRAVES, Mem. A.S.M.E., Brown & Sharpe Manufacturing Co., Providence, R. I.

Recorder: CLIFFORD P. WICKS, Mem. A.S.M.E., Yale & Towne Manufacturing Co., Stamford, Conn.

1—Current Practise in Surface Broaching*

By JOSEPH GESCHELIN, Engineering Editor, *Automotive Industries*, Philadelphia, Pa.

2—Progress in Machine-Shop Practise

By R. E. W. HARRISON, Mem. A.S.M.E., Chief, Machinery and Agricultural Implements Division, Department of Commerce, Washington, D. C.; Secretary, A.S.M.E. Machine Shop Practice Division

9:30 a.m. Vibration Room 1501

Auspices of Applied Mechanics Division

Presiding Officer: J. P. DEN HARTOG, Assoc-Mem. A.S.M.E., Assistant Professor of Applied Mechanics, Harvard University, Cambridge, Mass.

Recorder: F. M. LEWIS, Mem. A.S.M.E., Professor of Engineering, Webb Institute of Naval Architects, New York, N. Y.; Chairman, A.S.M.E. Applied Mechanics Division.

1—An Investigation of Axial Oscillations of Turbine-Generator Spindles

By J. G. BAKER, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

2—A Mathematical Solution of the Rotor-Balancing Problems*

By J. BROMBERG, Assoc-Mem. A.S.M.E., Brooklyn, N. Y.

3—Effect of Skewing and Pole Spacing on Magnetic Noise in Electrical Machinery*

By S. J. MIKINA, Jun. A.S.M.E., Mechanical Engineer, Westinghouse Research Laboratories, East Pittsburgh, Pa.

4—Dynamic Balancing of Rotating Machinery in the Field*

By E. L. THEARLE, Assoc-Mem. A.S.M.E., Research Engineer, General Electric Co., Schenectady, N. Y.

9:30 a.m. Iron and Steel Room 603

Auspices of Iron and Steel Division

Presiding Officer: GEORGE T. SNYDER, Mem. A.S.M.E., National Tube Company, Pittsburgh, Pa.

Recorder: J. H. HITCHCOCK, Jun. A.S.M.E., Morgan Construction Company, Worcester, Mass.; Secretary, A.S.M.E. Iron and Steel Division.

1—Manufacture of Large Seamless-Steel Tubes by the Tschulenk Forge-Rolling Process*

By ARTHUR J. HERSCHMANN, Mem. A.S.M.E., U. S. A. Agent for Vitkovice Steel Works of C. S. R., New York, N. Y., and L. TSCHULENK, Czechoslovakia

2—Progress in Iron and Steel Engineering

9:30 a.m. Textile Room 1101

Auspices of Textile Division

Presiding Officer: William L. Conrad, Mem. A.S.M.E., Consulting Engineer, New York, N. Y.; Chairman, A.S.M.E. Textile Division.

Recorder: M. A. Golrick, Jr., Mem. A.S.M.E., Dutchess Bleachery, Wappingers Falls, N. Y.; Secretary, A.S.M.E. Textile Division.

1—Survey on Lubricants Used in the Textile Industry

By C. H. Baxley, Mem. A.S.M.E., and C. M. Larson, Mem. A.S.M.E., Sinclair Refining Company, New York, N. Y. (Contributed by Lubrication Engineering Committee, A.S.M.E. Petroleum Division)

2—The Opportunity for Cost Reduction in Textile Manufacturing and Selling

By Sanford E. Thompson, Mem. A.S.M.E., President, The Thompson & Lichtner Co., Inc., Boston, Mass.

WEDNESDAY AFTERNOON, DECEMBER 5

12:30 p.m. Textile Luncheon Fraternity Clubs

1—Engineering Aspects of the Stretchout System

By J. J. McElroy, Superintendent, Maverick Mills, East Boston, Mass.

2:00 p.m. Fuels Auditorium

Auspices of Fuels Division, Power Division Cooperating

Presiding Officer: F. M. Van Deventer, Mem. A.S.M.E., Henry L. Doherty & Co., New York, N. Y.; Chairman, A.S.M.E. Fuels Division.

Recorder: W. G. Christy, Mem. A.S.M.E., Smoke Abatement Engineer, Department of Smoke Regulation, Hudson County, Jersey City, N. J.; Secretary, A.S.M.E. Fuels Division.

1—Pulverized-Fuel-Burning Experience at Buzzard Point Plant

By H. G. Thielscher, Mem. A.S.M.E., Mechanical Engineer, Potomac Electric Power Company, Washington, D. C.

2—The Economics of Preheated Air for Stokers

By R. E. Dillon, Mem. A.S.M.E., Superintendent, Generating Department and M. D. Engle, Mem. A.S.M.E., Assistant to Superintendent, Stationary Engineering Department, The Edison Electric Illuminating Co., Boston, Mass.

3—The Relative Grindability of Coal*

By Harold J. Sloman and Arthur C. Barnhart, Carnegie Institute of Technology, Pittsburgh, Pa.

2:00 p.m. Suggestion Systems Room 501

Auspices of Management Division, Elimination of Waste Committee

Presiding Officer: C. B. Auel, Mem. A.S.M.E., Manager, Employees Service Department, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.; Chairman, A.S.M.E. Elimination of Waste Committee.

Recorder: Charles A. Hescheles, Assoc-Mem. A.S.M.E., Consumers' Service Division, Brooklyn Union Gas Co., Brooklyn, N. Y.

1—Philosophy and Administration of Suggestion Systems (Published in the November, 1934, issue of *Mechanical Engineering*)

By Z. C. Dickinson, Professor of Economics, University of Michigan, Ann Arbor, Mich.

2—Operation of a Suggestion System

By Virgil M. Palmer, Mem. A.S.M.E., Engineer of Industrial Economy, Eastman Kodak Company, Rochester, N. Y.

2:00 p.m. Metal Cutting Room 502

Auspices of Special Research Committee on Cutting of Metals, Jointly With Machine Shop Practice Division

Presiding Officer: L. P. Alford, Mem. A.S.M.E., Editor, Ronald Press, New York, N. Y.

Recorder: Coleman Sellers, 3rd, Mem. A.S.M.E., Executive Engineer, William Sellers & Co., Inc., Philadelphia, Pa., Chairman, Cutting Metals Research Committee.

1—Relation Between Cutting Force, Temperature, and Tool Life When Cutting Steel With a Single-Point Tool

By O. W. Boston, Mem. A.S.M.E., and W. W. Gilbert, University of Michigan, Ann Arbor, Mich.

2—The Formation and Function of the Built-Up Edge

By Hans Ernst, Mem. A.S.M.E., Research Engineer, Cincinnati Milling Machine Company, Cincinnati, Ohio

3—Progress Report of Subcommittee on Metal-Cutting Data

By R. C. Deale, Mem. A.S.M.E., Secretary, Subcommittee on Metal-Cutting Data

2:00 p.m. Stress Analysis Room 1501

Auspices of Applied Mechanics Division

Presiding Officer: H. M. Westergaard, University of Illinois, Urbana, Ill.

Recorder: E. O. Waters, Assoc-Mem. A.S.M.E., Professor of Mechanical Engineering, Yale University, New Haven, Conn.; Secretary, A.S.M.E. Applied Mechanics Division.

1—Exact Construction of the $(\sigma_1 + \sigma_2)$-Network From Photoelastic Observations*

By Heinz P. Neuber, Technische Hochschule, Munich, Germany

2—New Method of Calculating Longitudinal Shear in Checked Wooden Beams*

By J. A. Newlin, G. E. Heck, and H. W. March, Forest Products Laboratories, Madison, Wis.

3—Collapse by Instability of Thin Cylindrical Shells Under External Pressure*

By D. F. Windenburg, Assistant Physicist, and Charles Trilling, U. S. Experimental Model Basin, Navy Yard, Washington, D. C.

4—Progress in Applied Mechanics

By E. O. Waters, Assoc-Mem. A.S.M.E., Professor of Mechanical Engineering, Yale University, New Haven, Conn.; Secretary, A.S.M.E. Applied Mechanics Division

2:00 p.m. Steam Tables Research Room 903

Auspices Special Research Committee on Steam Table Research

Presiding Officer: Arthur M. Greene, Jr., Mem. A.S.M.E., Dean, School of Engineering, Princeton University, Princeton, N. J.

Recorder: Theodore Smith, Jun. A.S.M.E., Brooklyn, N. Y.

1—Reports on Research Work

2—Report of International Steam Table Conference

2:00 p.m. Iron and Steel Room 603

Auspices of Iron and Steel Division, Jointly With Lubrication Engineering Committee

Presiding Officer: A. J. Boynton, Mem. A.S.M.E., Vice-President, H. A. Brassert & Co., Chicago, Ill.; Chairman, A.S.M.E. Iron and Steel Division.

Recorder: Charles H. Bromley, Assoc-Mem. A.S.M.E., Pure Oil Company, New York, N. Y.

1—Wire-Rope Research Report
By Special Research Committee on Wire Rope

2—Lubrication of Rolling Mills—A Symposium

Lubricants Used by Bethlehem Steel Corporation
By J. F. Pelly, Bethlehem Steel Corporation, Bethlehem, Pa.

Steel-Mill Lubricating
By B. S. Burrell, Inland Steel Company, Chicago, Ill.

Lubricants Used in Copper and Brass Mills
By Walter Clark, Mem. A.S.M.E., General Manager, Bridgeport Brass Company, Bridgeport, Conn.

4:30 p.m. Calvin W. Rice Lecture Auditorium

Dr. Calvin W. Rice's Contribution to International Friendliness

6:30 p.m. Annual Dinner **Hotel Astor**

THURSDAY MORNING, DECEMBER 6

9:30 a.m. Central Station Auditorium

Auspices Power Division, Fluid Meters Committee Cooperating

Presiding Officer: C. Harold Berry, Mem. A.S.M.E., Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

Recorder: R. G. Napier, Jr., Engineer, United Electric Light & Power Co., New York, N. Y.

1—High-Pressure-Steam and Binary Cycles as a Means of Improving Power-Station Efficiency*
By Gustaf A. Gaffert, Assoc-Mem. A.S.M.E., Assistant Professor of Heat Power Engineering, Worcester Polytechnic Institute, Worcester, Mass.

2—Fluid-Meter Nozzles*
By B. O. Buckland, Jun. A.S.M.E., Turbine Engineering Department, General Electric Company, Schenectady, N. Y.

9:30 a.m. Quality Control Room 501

Auspices of Management Division

Presiding Officer: M. F. Skinker, Brooklyn Edison Co., Brooklyn, N. Y.

Recorder: Joseph A. Piacitelli, Assoc-Mem. A.S.M.E., Consulting Industrial Engineer, New York, N. Y.

1—Aspects of Quality Control
By W. A. Shewhart, Bell Telephone Laboratories, New York, N. Y.

2—Control of Distribution
By T. H. Brown, Professor, Harvard University, Cambridge, Mass.

3—Progress Report on Management

9:30 a.m. Boiler Feedwater—I Room 502

Presiding Officer: S. T. Powell, Baltimore, Md.; Chairman, A.S.M.E. Boiler Feedwater Studies Committee.

Recorder: V. Zaffarano, Jun. A.S.M.E., Jackson Heights, Long Island, N. Y.

1—Progress Report on Research Work on Dissolved Oxygen
By C. H. Fellowes, Detroit Edison Co., Detroit, Mich.; Chairman, Subcommittee on Standardization of Water Analysis

2—Navy's Experience With the New Boiler Compound
By R. C. Adams, Jr., U. S. Naval Experimental Station, Annapolis, Md.

9:30 a.m. Aerodynamics Room 1501

Auspices of Aeronautic and Applied Mechanics Division, Institute of Aeronautical Sciences Cooperating

Presiding Officer: T. P. Wright, Mem. A.S.M.E., Curtiss Aeroplane & Motor Corporation, Buffalo, N. Y.

Recorder: Jerome Lederer, Assoc-Mem. A.S.M.E., Chief Engineer, Aero Insurance Underwriters, New York, N. Y.; Secretary, A.S.M.E. Aeronautic Division.

1—Boundary Layer Flow Near Flat Plate
By Hugh L. Dryden, Bureau of Standards, Washington, D. C.

2—A New Theory for Buckling of Thin Cylinders Under Axial Compression and Bending*
By L. H. Donnell, Mem. A.S.M.E., Engineer in Charge of Stress Analysis, Goodyear-Zeppelin Corporation, Akron, Ohio

3—Further Experiments on the Variation of the Maximum-Lift Coefficient With Turbulence and Reynolds' Number*
By Clark B. Millikan, Assoc-Mem. A.S.M.E., Assistant Professor of Aeronautics, California Institute of Technology, Pasadena, Calif.

4—The Design and Performance of an Axial-Flow Fan*
By L. S. Marks, Mem. A.S.M.E., Professor of Mechanical Engineering, and John R. Weske, Harvard Graduate School, Harvard University, Cambridge, Mass.

5—Progress in Aeronautical Engineering

9:30 a.m. Sugar Room 1101

Auspices of Process Division

Presiding Officer: F. M. Gibson, Mem. A.S.M.E., American Sugar Refining Co., Brooklyn, N. Y.

Recorder: Richard Kutzleb, Jun. A.S.M.E., Engelwood, N. J.

1—Mechanical Circulation in Vacuum Pans
By Alfred L. Webre, Mem. A.S.M.E., United States Pipe and Foundry Company, Burlington, N. J.

THURSDAY AFTERNOON, DECEMBER 6

2:00 p.m. Central Station Auditorium

Auspices of Power and Fuels Divisions

Presiding Officer: A. E. Grunert, Mem. A.S.M.E., Efficiency Engineer, Commonwealth Edison Company, Chicago, Ill.; Chairman, A.S.M.E. Power Division.

Recorder: R. G. Napier, Junior Engineer, United Electric Light & Power Co., New York, N. Y.

1—The Test Performance of Hudson Avenue's Most Recent Steam-Generating Units*
By P. H. Hardie, Assoc-Mem. A.S.M.E., and W. S. Cooper, Assoc-Mem. A.S.M.E., Research Bureau, Brooklyn Edison Co., Brooklyn, N. Y.

2—Ten Years of Stoker Development at Hudson Avenue
By J. M. Driscoll, Jun. A.S.M.E., and W. H. Sperr, respectively, Plant Equipment Engineer, and Assistant Plant Equipment Engineer, Mechanical Engineering Department, Brooklyn Edison Co., Brooklyn, N. Y.

3—Coal Charges for Banking, Lighting, and Burning Out Boiler Units
By George C. Eaton, Head, Mechanical Technical Generating Department, Edison Electric Illuminating Co., Boston, Mass.

4—Progress in Power
(Auspices of Power, Oil and Gas Power, Fuels, and Hydraulic Divisions)

2:00 p.m. Oil and Gas Power Room 501

Auspices of Oil and Gas Power Division

Presiding Officer: R. B. McColl, President, McIntosh & Seymour Corporation, Auburn, N. Y.

Recorder: E. J. Kates, Mem. A.S.M.E., Consulting Engineer, New York, N. Y.; Secretary, A.S.M.E. Oil and Gas Power Division.

1—Future of the Large Motorship

By Louis R. Ford, Mem. A.S.M.E., Editor, *Motorship*, New York, N. Y.; Chairman, A.S.M.E. Oil and Gas Power Division

2—Maintenance Schedule in a Diesel Central Station

By H. C. Major, Rockville Center, Long Island, N. Y.; Chairman, A.S.M.E. Subcommittee on Oil-Engine Power-Cost Report

3—Adjourn to Auditorium for "Progress in Power"

2:00 p.m. Boiler Feedwater Room 502

Auspices of Boiler Feedwater Studies Committee

Presiding Officer: T. E. Purcell, General Superintendent, Power Stations, Duquesne Light Company, Pittsburgh, Pa.; Vice-Chairman, Boiler Feedwater Studies

Recorder: Michael Porter, Long Island Lighting Co., Glen Head, N. Y.

1—A Critical Survey of Published Information Relating to the Embrittlement of Boiler Steel

By Everett P. Partridge and W. C. Schroeder, Non-Metallic Minerals Expt. Station, Bureau of Mines, New Brunswick, N. J.

2—The Solubility of Sodium Sulphate in Boiler-Water Salines as Related to the Prevention of Embrittlement—Progress Report No. 3

3—The Effect of Solution Composition on the Failure of Highly Stressed Boiler Steel—Progress Report No. 1

Both Reports By W. C. Schroeder and E. P. Partridge

2:00 p.m. Mechanical Springs Room 1501

Presiding Officer: J. R. Townsend, Assoc-Mem. A.S.M.E., Bell Telephone Laboratories, New York, N. Y.; Chairman, A.S.M.E. Mechanical Springs Committee.

Recorder: C. G. Edgerton, Crucible Steel Co., New York, N. Y.

1—Development of Elastic Springs

By A. V. De Forest, Consultant, Chatillon & Son, also Massachusetts Institute of Technology, Cambridge, Mass.

2—New Spring Formulas and New Materials in Precision Spring Scale Design

By Mortimer F. Sayre, Mem. A.S.M.E., Associate Professor of Applied Mechanics, Union College, Schenectady; and Consulting Engineer, John Chatillon & Son, New York, N. Y.

3—Analysis of Deflection and Stress in Helical Compression Springs

By H. C. Keysor, Mechanical Engineer, American Steel Foundries, Chicago, Ill.

2:00 p.m. Fluid Meters Room 903

Auspices of A.S.M.E. Research Committee on Fluid Meters

Presiding Officer: R. J. S. Pigott, Mem. A.S.M.E., Staff Engineer, Gulf Research & Development Corporation, Pittsburgh, Pa.; Chairman, A.S.M.E. Fluid Meters Committee.

Recorder: V. Zaffarano, Jun. A.S.M.E., Jackson Heights, Long Island, N. Y.

1—Calibration of Rounded-Approach Orifices*

By J. F. Downie Smith, Assoc-Mem. A.S.M.E., Instructor in Mechanical Engineering, Harvard University, Cambridge, Mass.

2—The V-Notch Weir for Hot Water*

By Ed S. Smith, Mem. A.S.M.E., Builders Iron Foundry, Providence, R. I.

3—Progress Report by Hydraulic Division

PROGRAM AT STEVENS INSTITUTE, HOBOKEN, N. J.

3:00 p.m. Economics Auditorium

Presiding Officer: Harvey N. Davis, Mem. A.S.M.E., President, Stevens Institute of Technology, Hoboken, N. J.

Recorder: George Hagemann, Mem. A.S.M.E., Editor, Alexander Hamilton Institute.

Discussion of Engineering Economics

6:30 p.m. Invitation Dinner Castle Stevens

8:00 p.m. Gantt Medal Presentation Auditorium

Presentation of Gantt Medals to Wallace Clark by Dr. Lillian N. Gilbreth; and to Horace Cheney, by Col. Malcolm Rorty

8:30 p.m. Towne Lecture Auditorium

By Dexter S. Kimball, Past-President, A.S.M.E., Dean of the College of Engineering, Cornell University, Ithaca, N. Y.

OUTLINE OF A.S.M.E. ANNUAL MEETING PROGRAM

Monday, Dec. 3, 10:00 a.m. Council Meeting, 502; 2:00 p.m. Business Meeting, Aud.

	Tuesday, Dec. 4	Wednesday, Dec. 5	Thursday, Dec. 6
9:30 a.m.	Welding Vs. Casting, Aud. Heat Transfer, 501 Railroad, 502 Bearing Analysis, 1501 Apprentice Training, 1101 Fans, 903	Indus. Power, Aud. Budgeting, 501 Broaching, 502 Vibration, 1501 Textile, 1101 Iron & Steel, 603	Cent. Station, Aud. Quality Control, 501 Boiler Feedwater, 502 Aerodynamics, 1501 Sugar, 1101
12:30 p.m.		Textile Luncheon, Fraternity Clubs	
2:00 p.m.	Domestic Heating, Aud. Safety, 501 Railroad, 502 Bearing Practise, 1501 Materials, 903 Heat Transfer, 603 Engineering History, 1100	Fuels, Aud. Suggestion Systems, 501 Metal Cutting, 502 Stress Analysis, 1501 Steam Tables, 903 Iron & Steel, 603	Cent. Station, Aud. Oil & Gas Power, 501 Boiler Water, 502 Mech. Springs, 1501 Fluid Meters, 903 Econ., Stevens, 3:00 p.m.
	Thurston Lecture, 4:30 p.m. Pres. Night, 8:30 p.m.	Rice Lecture 4:30 p.m. Aud. Dinner, 6:30 p.m., Astor	Towne Lecture at Stevens Inst., 8:30 p.m.

WHAT'S GOING ON

Actions of the A.S.M.E. Executive Committee

At the meeting of the A.S.M.E. Executive Committee on September 19, the following important actions were taken:

FINANCES

Discussion of routine financial matters and a review of a statement of income and expense provoked comment on the favorable showing, and in a formal vote the Executive Committee expressed its appreciation to the committees, members of the Society, and the staff for their cooperation, loyalty, and devotion in maintaining the present low rate of expenditures.

MEMBERSHIP STATUS

Upon recommendation of the Board of Review established to clarify the present membership status it was voted that a member whose promotion is pending who chooses loss of seniority will have his dues arrears canceled upon payment of one year's dues plus five dollars, but his election to the higher grade will be void until the promotion fee is paid. For members choosing the loss-of-seniority plan who completed payment under this plan by September 30, 1934, the "date of election" shall be October 1, 1933.

JOURNAL OF APPLIED MECHANICS

Upon the joint recommendation of the Executive Committee of the Applied Mechanics Division, and the Committees on Publications and Professional Divisions it was voted to approve the plan for publishing a Journal of Applied Mechanics. (See a more detailed announcement on page 706.)

CAPITAL-GOODS INDUSTRIES COMMITTEE

After detailed discussion on the recommendations appended to the report of the Capital-Goods Industries Committee published in the October, 1934, issue of Mechanical Engineering, it was voted to authorize the president to appoint a committee, not necessarily of members of the Society, to review, in cooperation with other sponsor bodies, the operation of the Engineering Societies Employment Service; also to request the American Engineering Council to determine the cost of arranging for immediate transmission to members of the Society of information in regard to all Federal opportunities for engineering employment and engineering work, and to suggest the most feasible means of doing so; also to authorize the president to appoint a committee to determine whether or not it is practicable to conduct a publicity program to stimulate the initiation of local construction or modernization projects requiring engineers and engineering work; and finally to assist constructively in every proper way in building up public confidence. In discussing this final action the committee saw the need for close cooperation with the Durable Goods Industries Committee, elected by the Code Authorities at the close of the Conference of Code Authorities in Washington, March 8, 1934.

As a practical aid to individuals seeking employment it was voted to approve the recommendation of the Committee on the Capital-Goods Industries and the Professional Engineers' Committee on Unemployment that a suitable pamphlet on "Finding Work" be printed in Mechanical Engineering (see pages 662 to 670 of this issue) and reprinted for general distribution at a price sufficient to cover the cost.

APPOINTMENTS

The following appointments were reported: Committee on Education and Training for the Industries, John Younger; Committee on Local Sections, Junior advisory members, Stanley E. Oren, Jesse M. Tucker, Robt. J. Davis, and Francis X. Krogmann; Tellers of Election, Gilmoure N. Cole, Richard Kutzleb, Jr., and V. M. Zafferans; Pure Air Committee, W. F. Keenan, Jr. (to fill the unexpired term of G. W. Bach); Boiler Code Subcommittee on Special Design, D. B. Rossheim; John Fritz Medal Board of Award, Col. Paul Doty; Joint Committee (with A.I.M.E.) on the study of coal, E. B. Ricketts, Alex. D. Bailey, E. H. Tenney, A. L. Penniman, Jr., and H. Drake Harkins.

Third International Steam Table Conference, Sept. 17–22

It was an interesting coincidence that during the week of the international yacht races off Newport a group of international experts on the thermal properties of steam was conferring in the United States. The Third International Steam Table Conference convened in Washington on Monday, September 17, 1934, at the National Bureau of Standards. Dr. Lyman J. Briggs, Director of the Bureau, opened the first session of the conference and in his address he extended greetings on behalf of the Bureau to the delegates of the conference and emphasized the great value and importance of international scientific cooperation.

The list of official delegates to this conference is as follows:

Great Britain:

Mr. A. C. G. Egerton, F.R.S., Oxford University

Mr. G. S. Callendar, Imperial College of Science, London

Mr. H. L. Guy, Chief Engineer, Mechanical Engineering Department, Metropolitan-Vickers Electrical Company, Manchester

Mr. I. V. Robinson, British Electrical & Allied Manufacturers' Association, London

Germany:

Prof. Dr.-Phil. F. Henning, Director, Physikalisch Technischen Reichsanstalt, Berlin

Prof. Dr.-Ing. E. Schmidt, Technische Hochschule, Danzig-Langfuhr

Prof. Dr.-Ing. H. Hausen, Technische Hochschule, München

Dr.-Ing. W. Koch, Technische Hochschule, München

Dr.-Ing. F. Michel, Swarthmore, Pa.

United States:

Dr. H. N. Davis, President, Stevens Institute of Technology, Hoboken, N. J.

Dr. F. G. Keyes, Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. N. S. Osborne, Heat and Power Division, National Bureau of Standards, Washington, D. C.

Prof. J. H. Keenan, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. H. C. Dickinson, Chief, Heat and Power Division, National Bureau of Standards, Washington, D. C.

Mr. Geo. A. Orrok, Consulting Engineer, New York, N. Y.

Dr. L. B. Smith, Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

Mr. C. B. Le Page, Assistant Secretary, The American Society of Mechanical Engineers, New York, N. Y.

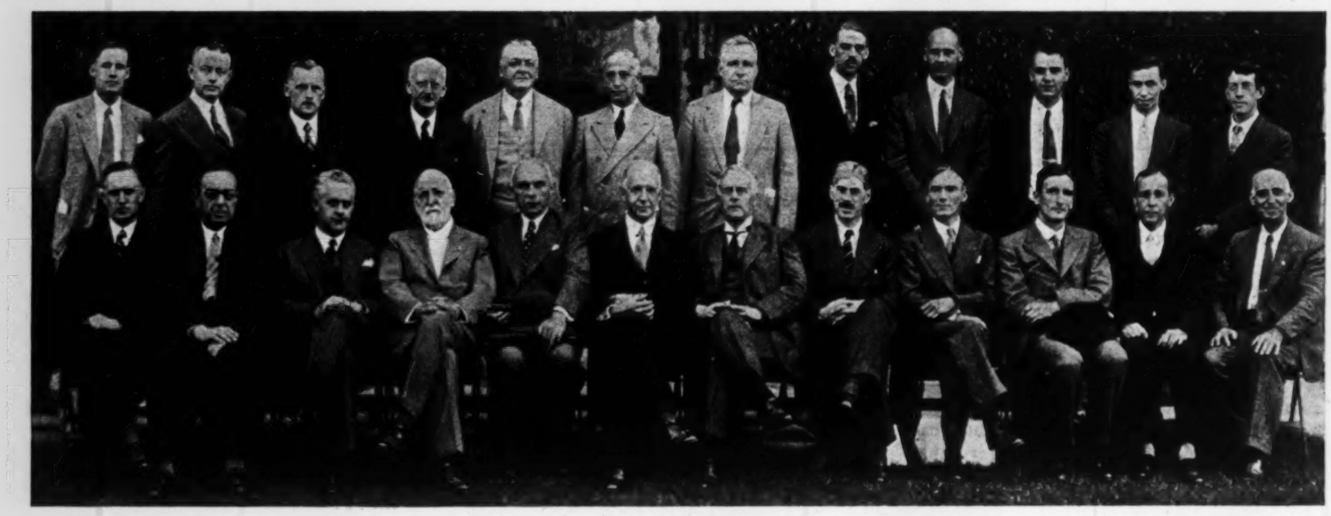
Visitor from Austria:

Dr.-Ing. Erich J. M. Honigmann, Acting Director, Materials Testing Laboratory, Engineering and Trade Museum, Vienna.

Mr. Fred M. Feiker, executive-secretary of the American Engineering Council, extended greetings on behalf of the engineering societies of the United States.

Dr. Alex Dow, chairman of the A.S.M.E. Special Research Committee on the Thermal Properties of Steam, then took the chair and greeted the delegates in his inimitable way. In his opening remarks he stressed the importance of general international agreement on the thermal properties of steam so that there might be complete understanding between the manufacturers and users of steam apparatus and that important economies might be attained in the design and construction of power machinery.

The responses for the visiting delegations were made by Henry L. Guy for Great Britain, by F. Henning for Germany, and by I. Vincent Robinson for Czechoslovakia. The latter spoke for Dr. Jaroslav Havlicek who was not able to attend the conference. In response to a request from Dr. Dow, Dr. Erich J. M. Honigmann, a guest from Austria, conveyed



PARTICIPANTS IN STEAM TABLE CONFERENCE AT BUREAU OF STANDARDS

(*Left to right, standing:* C. G. Worthington, F. Michel, E. Schmidt, G. A. Orrok, F. M. Feiker, C. B. Le Page, E. F. Mueller, E. J. M. Honigmann, J. H. Keenan, D. C. Ginnings, E. F. Fiock, H. F. Stimson. *Seated:* H. Hausen, W. Koch, H. L. Guy, A. Dow, F. Henning, L. J. Briggs, I. V. Robinson, A. C. G. Egerton, F. G. Keyes, G. S. Callendar, N. S. Osborne, H. C. Dickinson.)

to the conference the greetings of those in his country who were interested in the properties of steam.

The working subcommittee was then appointed with I. V. Robinson as chairman and with the following members: *British:* Messrs. Guy, Egerton, and Callendar; *German:* Messrs. Henning, Koch, Hausen, Schmidt, and Michel; *American:* Messrs. Osborne, Keyes, and Keenan. Contributions which had not been previously mailed to the delegates were then distributed.

The session adjourned at 11:00 a.m. and the delegates proceeded to the steam-research laboratory of the Bureau of Standards where Dr. Osborne described in detail the construction and operation of the apparatus used in the Bureau's determinations of (1) the pressure-temperature relation in the saturation region, (2) the enthalpy or total heat of the saturated liquid, and (3) the enthalpy of the saturated vapor.

At noon Dr. Briggs and the Bureau staff entertained the delegates and their ladies at luncheon, following which the party divided into groups for further visits to the steam research laboratory, to other parts of the National Bureau of Standards, and for automobile trips to points of interest in and around Washington. At 5:30 p.m. the delegates met at the Hotel Broadmoor for an informal dinner with the officers and members of the Washington Section of the A.S.M.E. and their friends. At 8:00 p.m. the delegates left Washington by train for Boston.

CONFERENCE IN CAMBRIDGE

The party was met at the Back Bay Station, Boston, by the local committee and conveyed by a special bus to the Walker Memorial at the Massachusetts Institute of Technology where breakfast was served. The delegates then assembled in the main lecture room of the Eastman Chemical Laboratories where they were formally greeted by Dr. Karl T. Compton, president of the Institute. He recalled the fact that the present steam-research program in the United States was begun in Cambridge at the conference held at Harvard University in 1921.

Dr. Compton expressed the belief that the research workers in the properties of steam were now ahead of the research workers in metallurgy. He stated that metals which will withstand the high pressures and temperatures desired in steam apparatus have not as yet been developed. He hazarded the guess that new uses would be found for steam, now that the experts had obtained experimentally and agreed upon its thermal properties. Dr. Harvey N. Davis responded for the delegates.

This session was followed by an inspection of the apparatus for steam research and the equipment for investigating the international scale of temperature in terms of the thermodynamic scale of temperature. This equipment has been operated by Dr. Beattie under the direction of Dr. Keyes. The Spectroscopic Laboratory, the Van der Graaf high-tension apparatus, the Bush computing machine, and other equipment of interest were inspected by the delegates as they desired.

A luncheon was tendered the conference by the Institute in Walker Memorial. It was attended by President James Bryant Conant, of Harvard University, President Karl T. Compton, of Massachusetts Institute of Technology, and Dr. Harvey N. Davis, President of Stevens Institute of Technology, and other distinguished guests. Following the luncheon the conference reconvened in the Eastman Laboratory where Dr. James A. Beattie, associate-professor of physico-chemical research, presented a paper giving his preliminary results on the relation between the international scale of temperature and the thermodynamic scale from zero to the boiling point of sulphur. This was followed by a tea after which the delegates departed by bus to the India Wharf of the Eastern Steamship Company where they boarded the S. S. *New York* for New York.

CONFERENCE IN NEW YORK

At 10:30 a.m. the delegates assembled in the Council Room of the A.S.M.E. headquarters for the third session of the conference. There were in attendance G. S. Callendar, H. N. Davis, H. C. Dickinson, A. C. G. Egerton, F. O. Ellenwood, E. F. Fiock, H. T. Gerry, D. C. Ginnings, H. L. Guy, H. Hausen, F. Henning, E. J. M. Honigmann, J. H. Keenan, F. G. Keyes, W. Koch, C. B. Le Page, L. S. Marks, F. Michel, Geo. A. Orrok, N. S. Osborne, Calvin W. Rice, E. L. Robinson, I. V. Robinson, E. Schmidt, L. B. Smith, H. F. Stimson, M. S. Van Dusen, and C. G. Worthington.

Dr. H. N. Davis presided in the absence of Dr. Dow and Dr. Rice welcomed the conference on behalf of The American Society of Mechanical Engineers. He stated that the A.S.M.E. was grateful for the success of the international steam-table work and also for the fact that the Society had, in this way, been able to serve as an instrument for the advancement of learning. He expressed the hope that this international conference group might be preserved and that support would be obtained to continue its work, perhaps in other fields. Before adjourning this plenary session to make way for a meeting of the subcommittee, it was voted that the secretary send greetings by cable to the following gentlemen who had attended the first and second conferences: Dr. Max Jakob and Dr. W. Fritz; Dr. Jaroslav Havlicek and Prof. L. Miskovsky; Dr. O. Knoblauch and Dr. R. Mollier. Greetings were also sent to Dr. Fred R. Low, chairman, A.S.M.E. Power Test Codes Committee.

Immediately after the adjournment of the third plenary session, the subcommittee met for the purpose of considering contributions of new experimental evidence and preparing a report for the revision and extension of the current international skeleton table. The three succeeding days provided for this work proved barely sufficient for consideration of the large amount of new data at hand, but by diligent and intensive effort this work was completed and reported to the final plenary session, subject to final verification and approval by the several delegations.

FINAL SESSION

The fourth and final plenary session of the conference was held on Saturday, Sept. 22, at the A.S.M.E. headquarters with Dr. Davis in the chair. The principal business of this session was to receive and act on the report of the working subcommittee. This report was presented by I. V. Robinson and several of the points were discussed by the conference. The final technical report of the Third International Steam Table Conference will, however, not be available until a tentative draft prepared by the chairman of the subcommittee and distributed by the secretariat of the conference has been approved by the several delegations.

It can be stated, however, that the results of the conference as contained in the report will mark a substantial advance toward completeness and accord in the data upon which steam tables are based. The following brief outline of the results will convey an idea of the extent of this progress as compared with the results of the Second Conference of 1930.

The table of definitive values and tolerances for pressures, volumes, and enthalpy of saturated water and steam was revised and enlarged by including values at every ten-degree interval from 0 C to 370 C, and every one-degree interval from 371 C to 374 C. This provides 42 definitive fixed points in place of the 10 points in the skeleton table of 1930. The range is extended from the previous limit at 350 C (662 F, 2400 lb per sq in.) to 374 C (705 F, 3200 lb per sq in.). Tolerances are generally reduced, especially in many places where new experimental evidence has been confirmed by independent investigations. Except for a few minor items requiring further experimental verification, the saturation table may be considered as adequate in extent, completeness, and veracity for the compilation or checking of working tables.

After discussion it was agreed that the units of length, mass, pressure, temperature, and heat energy as adopted by the First International Conference of London, 1929, be retained, and that a table of conversion factors be included in the report. The value to be used by the Conference for the number of absolute joules equivalent to one international electrical joule was taken as 1.0003, pending future authoritative international action.

SOCIAL ACTIVITIES

There were social as well as technical activities of the conference. On Wednesday evening, September 19, the A.S.M.E., its Research Committee, and the A.S.M.E Special Research Committee on the Thermal Properties of Steam acted as hosts at a dinner held in the Hotel Astor in honor of the visiting delegates. One hundred and ninety-two engineers and ladies attended. George L. Bourne, a member of the Special Research Committee, was chairman of the dinner committee. On Friday evening the visiting delegates entertained their American colleagues at a dinner at the Waldorf-Astoria Hotel.

About 200 persons attended the dinner at the Hotel Astor. Alex Dow, past-president, A.S.M.E., and Chairman of the special research committee, acted as presiding officer and proposed the toast "Homage to Caesar." Col. Paul Doty, president, A.S.M.E., welcomed the distinguished guests from across the water. Following the dinner, Dr. Harvey N. Davis, president, Stevens Institute of Technology, acted as toastmaster. For the Conference he presented a suitably inscribed silver dish to Geo. A. Orrok in tribute to his services on behalf of steam-table research.

Henry L. Guy, chief of the British delegation, Dr. F. G. H. Henning, chief of the German delegation, and I. V. Robinson, member of the British delegation responded to toast for the British, German, and Czechoslovakian workers, respectively. Dr. Arthur M. Greene, Jr., member of the A.S.M.E. special research committee, spoke on the steam tables produced in the United States prior to 1921. (It is expected that Dr. Greene's address will appear in a later issue of MECHANICAL ENGINEERING.) The final speaker was Dexter S Kimball, dean, College of Engineering, Cornell University, and past-president, A.S.M.E., who stressed the importance of international cooperation. During the evening the University Singers sang a number of negro songs and others typical of this country.—C. B. LE P.

Geo. A. Orrok Honored

A PLEASANT and unexpected feature of the dinner in connection with the Third International Steam Table Conference, at the Hotel Astor, New York, September 19, was the presentation of an inscribed silver dish to Geo. A. Orrok, for his services in stimulating the development of research in the properties of steam and the international steam table conferences.

The A.S.M.E. Special Research Committee on the Thermal Properties of Steam was formed in 1921 as a result of recommendations made at a conference at Harvard University called by Mr. Orrok. (See MECHANICAL ENGINEERING, August, 1921, pp. 553 and 554.) Mr. Orrok served as chairman of this committee until 1929, when Alex Dow, president Detroit Edison Co., assumed the chairmanship.

Dr. Harvey N. Davis, who acted as toastmaster at the dinner, made the presentation to Mr. Orrok. Asking his audience to imagine him clothed in academic garb, Dr. Davis read the following citation:

> GEORGE ALEXANDER ORROK, honored lecturer at a score of institutions of learning all over the world, from no one of which did you ever deign to graduate, whose words of wisdom to students are perhaps the more eagerly heard for that very reason, generous and effective helper and adviser of every aspiring engineer who crosses your path, be he young or old, and above all, father of the American Steam Research Program which was conceived in your vision and courage, and born of your devoted labor.
>
> By virtue of the authority vested in me by all these your friends, I hereby confer on you, this token of our affection and esteem, the inscription on which is,
>
> "In tribute to Geo. A. Orrok, Engineer, whose vision, energy and enthusiasm promoted the union of science and engineering by bringing together, in the spirit of James Watt and Joseph Black, the research workers of the world to determine the thermal properties of steam. Presented with warm affection and sincere admiration of the participants in the Third International Steam Table Conference. New York City, N. Y., Sept. 19, 1934."

Printing Industries Meeting Philadelphia, Oct. 8 and 9

UNDER the auspices of the Printing Industries Division of the A.S.M.E., there was held in Philadelphia on October 8 and 9 the Fifth Annual Conference of the Technical Experts in the Printing Industry. The sessions were held at the Benjamin Franklin Hotel and at the Franklin Institute. Acting as joint hosts were the Philadelphia Local Section of the A.S.M.E., the Philadelphia Engineers' Club, the United Typothetae of Philadelphia, and the Philadelphia Club of Printing House Craftsmen. There was an attendance of about four hundred.

The latest developments as the result of research in all branches of the graphic arts and the most modern printing processes and machinery were discussed in the papers presented. As a part of the program, inspection trips were made through the great plants of the Curtis Publishing Company and the Lanston Monotype Machine Company. The graphic-arts exhibits housed in the Franklin Institute were also visited. Machinery and processes relating to the papers presented were displayed in the foyer of the hotel ballroom, in which most of the sessions were held.

This convention also was made the occasion for the organization meeting of an institute for research in all branches of the graphic arts. The membership is to be open to all interested, and the findings or the methods developed to be given to the industry at large. The charter members, all of whom paid the registration fee, numbered 176.

The technical papers and the authors included the following: "Photomechanics of Color Photography," Harry A. Groesbeck, Jr., Country Life-American Home Corporation; discussed by Harold Fowler, technical supervisor, Bassani Processes, Inc. "Synthetic Resins as a Process Roller Material," A. L. Freedlander, president, The Dayton Rubber Mfg. Co.; discussed by W. S. Robinson, manager, The McCall Co., and E. R. Bridgewater, manager of chemicals division, E. I. du Pont de Nemours & Co. "Rubber Plates for Letterpress Printing," Ralph Schwarz and J. Homer Winkler, Ace Electrotype Co. "Technology of Rubber-Plate Manufacture," W. J. Ruscoe, technical representative, B. F. Goodrich Co.; discussed by H. W. Haydock, president, Royal Electrotype Co. "Photomechanical Reproduction of Offset Plates," W. C. Heubner, The Heubner Laboratories; discussed by H. A. Bernhardt, Latham Litho & Printing Co., and Randolph T. Ode, president, Providence Lithograph Co. "Recent Developments in Offset Printing," Burt D. Stevens, Miehle Printing Press & Mfg. Co. "From Design to Type—Processes in the Manufacture of Monotype Matrices," Sol Hess, assistant art director, Lanston Monotype Machine Co. "Comparison of the Reproductive Quality of Aquatone and Other Printing Processes," Maurice N. Weyl, president, Edward Stern & Co.; discussed by William C. Heubner. "New Developments in Color Rotogravure Printing," G. A. Friess, superintendent of rotogravure department, *The Daily News*, New York, N. Y.; discussed by M. Raoul Pellissier, director, Gravure Foundation of America, and W. S. Weichselbaum, Neo-Gravure Printing Co. (the Cuneo Press.) "Printing on Metal Paper," R. E. Hunt, Reynolds Metals Co.; discussed by Watson B. Laughton, superintendent of pressroom, Cuneo Eastern Press, and R. P. Schambach, president, American Label Co.

As guests of honor at the dinner on the first night of the session there were Dr. M. Yano, director of the Imperial Japanese Printing Office; Hon. Augustus E. Giegengack, the Public Printer of the United States; Hon. George H. Carter, the former Public Printer; and also two great-great-great-grandsons of Benjamin Franklin, Franklin Bache Huntington, an architect, and Russell Duane, a member of the bar.

Those presiding over the sessions and the dinner and luncheons were Walter D. Fuller, vice-president, Curtis Publishing Co.; Edward Epstean, past-president, Photo-Engravers Board of Trade of New York; Matthias D. Maull, president, Patterson & White; John Clyde Oswald, chairman of the Printing Industries Division, A.S.M.E.; Prof. G. E. Crofoot, University of Pennsylvania, and chairman of the Philadelphia Local Section, A.S.M.E.; V. Winfield Challenger, director of printing, N. W. Ayer & Son, Inc., and secretary of the Philadelphia Club of Printing House Craftsmen; H. C. Cole, president, Acme Gear Co.; Dr. Howard McClenahan, secretary, the Franklin Institute.

The organization of a printing research institute was introduced with a résumé of the history and accomplishments of printing research in the United States, by John Clyde Oswald, chairman, Printing Industries Division, A.S.M.E., and by Edward Pierce Hulse, secretary, Printing Industries Division, A.S.M.E., who spoke on "What England, Germany, Japan, and France Have Accomplished," followed by the proposed plan, "Organizing the Institute," by Arthur C. Jewett, former director of the College of Industries, Carnegie Institute of Technology, and now connected with the Regional Labor Board, and chairman of the research and survey committee of the Division for the last six years.

The organization committee, of which V. Winfield Challenger was chairman, made the following recommendations:

> That the name shall be the "Graphic Arts Research Bureau."
>
> That the objects of the bureau shall be to act as a clearing house for graphic-arts research and the collection, correlation, and distribution of research information pertaining to the industry, and the sponsorship of research work.
>
> That the membership shall be made up of those who are registered at the conference as charter members and that the question of association and company membership shall be left for development by the executive committee. Note: Charter membership, on the payment of the $2 registration fee, shall be kept open until December 31, 1934. The committee shall endeavor to bring in as affiliated organizations all of the organizations and associations connected with the graphic arts.
>
> That the executive committee, made up of a chairman, a vice-chairman, and a secretary-treasurer, and twelve additional members, be appointed to serve for one year. The committee recommends the following: Chairman, Arthur C. Jewett, Pittsburgh; vice-chairman, Lewis W. Trayser, Philadelphia; secretary-treasurer, V. Winfield Challenger; and Charles Clarkson, Edward Epstean, Harry Gage, A. E. Giegengack, William Clement Glass, Edward Pierce Hulse, Thomas R. Jones, William R. Maull, John Clyde Oswald, John W. Park, Burt D. Stevens, and J. Homer Winkler.
>
> That the executive committee prepare and present for adoption a constitution, that they perfect organization plans, and that they be empowered to function during the coming year in any research work that they may deem advisable and in the furthering of the bureau's development.

Upon being put before the delegates present, the foregoing committee report was unanimously adopted. Two pledges were immediately made of funds for the organization work totaling $1200.

The Philadelphia Committee on Arrangements, upon which fell all of the burden of planning for and of arranging the technical conference was as follows: Walter D. Fuller, *chairman*, first vice-president and secretary, Curtis Publishing Co.; Lewis W. Trayser, *vice-chairman*, assistant superintendent, Curtis Publishing Co.; Joseph S. Pecker, *secretary*, chief engineer, Machine and Tool Designing Co.; William R. Maull, vice-president, Dill & Collins, Inc., and chairman of Paper and Pulp Committee, Printing Industries Division, A.S.M.E.; V. Winfield Challenger, director of printing, N. W. Ayer & Son, Inc., and secretary, Philadelphia Club of Printing House Craftsmen; William Meeks, manager, Philadelphia Typothetae; and H. S. Harris, The Franklin Institute.

This Month's Authors

SAMUEL S. BOARD, placement specialist and sometime director of the Yale Graduate Placement Bureau, Inc., has made a business of bringing men and jobs together and sorting out round pegs and square holes. He speaks frequently before undergraduates and last year at Columbia University organized a course on the engineer and his work.

Z. C. Dickinson, professor of economics at the University of Michigan, author of the paper on "Suggestion Systems," has written and studied extensively on subjects dealing with the relations of economics and psychology and industrial research.

P. A. Kinzie, Bureau of Reclamation engineer, has been noted in this column many times recently. His description of engineering work on the hydraulic valves and gates at Boulder dam will be concluded next month.

Viktor Kaplan, 1876-1934

AT UNTERACH, on the Attersee, on August 24, 1934, Prof. Dr. techn. E. h. Viktor Kaplan, aged 57 years, died as a result of complications following a heart attack. Kaplan was born November 27, 1876, in Mürzuschlag, studied at the Polytechnic Institute in Vienna, and was a student of Radiger. In 1903 he became the designing engineer for Ganz & Co., in their Loebersdorfer Works, where he was engaged in the construction of hydraulic turbines, and there found the first stimulus to his great technical accomplishments. After a broader experience as designing engineer at the German Polytechnic School in Brünn, Bohemia, he succeeded, in 1913, A. Musil as professor of mechanical engineering. He retained this position up to the past year when he was compelled to retire because of ill health. The German Polytechnic School in Prague and in Brünn conferred on him the honorary doctor degree.

Kaplan's life work was dedicated to the problem of increasing the velocity of the hydraulic turbine, to constructing turbines with high rotative speeds, so that the turbines, as well as the generators, are held within small dimensions. After many trials with various wheels and through logical deductions he developed the present Kaplan wheel. In the line of developing high-speed turbines, the draft-tube problem became considerably more difficult to solve, and because of his many experiments Kaplan was able to produce new fundamental ideas. His third outstanding achievement is the introduction of blade adjustment. This made it possible to maintain an almost constant efficiency in spite of a changing load in the turbines from practically one-third to full, and thus to insure an equally efficient use of the available water at all times. During the development of the high-speed turbine from the Kaplan wheel, difficulties arose in the form of cavitation defects, but after tenacious labor on the part of the inventor methods were pointed out of developing wheels free from cavitation defects. (Translated from *R. T. A. Nachrichten*, by L. M. Tichvinsky, Research Laboratories, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.)

H. O. Croft Addresses Mexican Engineers

FOLLOWING the Semi-Annual Meeting of the A.S.M.E. at Denver, Colo., Prof. Huber O. Croft, of the Department of Mechanical Engineering of The State University of Iowa, traveled to Mexico City, Mexico, where, on August 8, he and Prof. P. S. Biegler, of the University of Southern California, addressed a joint meeting sponsored by Manuel Gomez Morin, rector of the National University of Mexico, and Ezequiel Ordonez, president of the Association of Engineers and Architects of Mexico, in the Auditorium of the Mexican Society of Geography and Statistics and the Academy of Sciences. The audience of approximately one hundred represented the institutions mentioned and of the Mexican Society of Mechanical and Electrical Engineers, including local members of the A.S.M.E.

Professor Biegler spoke on "Development of Power at the Boulder Dam and the Transmission to Southern California," and Professor Croft on "The Aerodynamics of Dust." Professor Croft's illustrated talk was based on his paper at Denver entitled, "The Calculation of the Dispersion of Flue Dust and Cinders from Chimneys." While the flue-dust problem is not an important one in Mexico City, severe dust storms in the winter that result from the sweeping of high winds over nearby dry lake beds are a source of annoyance and expense. Professor Croft was able to throw light on this perplexing problem.

During his stay in Mexico, Professor Croft called on members of the A.S.M.E. in Mexico City and vicinity and discussed with them the problems of the Society.

Libraries Association Plans Petroleum Division

AT A MEETING of the Special Libraries Association a Petroleum Section was formed within their Science-Technology group. The intention of this section is: To bring in closer contact all librarians whose work deals with petroleum and its allied subjects; to make a decimal classification of petroleum subjects; to facilitate inter-library loans; to exchange duplicate material. Persons interested are requested to write Albert Althoff, Librarian, General Petroleum Corporation of California, 2525 East 37th Street, Los Angeles, Calif.

Stevens Centenary of Transportation

A PROCLAMATION by A. Harry Moore, Governor of the State of New Jersey, calls attention to the fact that in 1884 the Camden and Perth Amboy Railroad from Bordentown to Amboy, and, in the same year, the Delaware and Raritan Canal from New Brunswick to Bordentown were opened to the public. Col. John A. Stevens was a prime mover in both of these significant developments in transportation in the state of New Jersey. The Governor, therefore, has proclaimed that during the months of October and November, 1934, the Stevens Centenary of Transportation Progress in New Jersey shall be observed throughout the state, in memory of Colonel Stevens and "other pioneers of progress."

A.S.T.M. 1935 Meeting, Detroit, June 24–29

THE 1935 (Thirty-Eighth) Annual Meeting of the American Society for Testing Materials will be held at the Book-Cadillac Hotel, Detroit, June 24 to 29. It is planned also to hold the Third A.S.T.M. Exhibit of testing and research apparatus, with related equipment, in conjunction with the meeting.

Public Works Courses at N. Y. U.

IT HAS been announced that Prof. Thorndike Saville, of New York University, has planned and arranged a curriculum in the College of Engineering to train graduate and undergraduate engineers for careers in public works and the construction industry. Participating in the new curriculum will be many engineers, public officials, and economists. Five courses will be included: public-works principles and practises, construction codes and labor problems, industrial organization, engineering economics and finance, and constructors' organization and equipment.

F. T. Sisco, of Iron Alloys Committee, Visits Europe

FRANK T. SISCO, editor of the Iron Alloys Committee visited more than twenty leading metallurgists at Berlin, Düsseldorf, Aachen, Essen, and Pilsen, in June, making useful personal contacts. He collected much valuable information for the Alloys of Iron Research which The Engineering Foundation is carrying on with the cooperation of Battelle Memorial Institute, National Bureau of Standards, Lehigh University, Carnegie Institute of Technology, Massachusetts Institute of Technology, American Iron and Steel Institute, and a number of firms and individuals. The research is sponsored by the American Institute of Mining and Metallurgical Engineers. The American Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers also participated in the preliminary stages.

The purposes of the trip were: (1) to discover, if possible, the opinions held by prominent German and Czech metallurgists concerning alloys of iron research and to explain in detail, to those unfamiliar with the work, what The Engineering Foundation is trying to accomplish; (2) to establish more friendly relations with fellow workers in Germany and Czechoslovakia; (3) to obtain from foreign metallurgists a critical opinion of the subject matter and usefulness of the books; (4) to secure for future volumes important data from unpublished German dissertations.

Reviews of two of the three books published by the Iron Alloys Committee will be found in MECHANICAL ENGINEERING, August, 1933, p. 521, and September, 1934, p. 571.

The technical men of Skoda works (Pilsen, Czechoslovakia) were thoroughly familiar with the books already published by The Engineering Foundation. In Germany, where the importation of books is more difficult, the work was not so well known In both countries the opinion was unanimous that the project was of great value to ferrous metallurgists everywhere, and the hope was expressed that it would be carried to a successful conclusion.

At all of the laboratories and publishing houses visited fullest cooperation was offered to the Iron Alloys Committee in making the books as comprehensive and complete as possible. A procedure was worked out whereby unpublished data may be made available for inclusion in the future volumes.

Exposition of Power and Mechanical Engineering New York, Dec. 3 to 8

THE Eleventh National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York, Dec. 3 to 8. It is announced that the keynote of the exposition is to be the saving in power costs, and the need for modernization and replacement of obsolete equipment. The executive offices of the exposition are at the Grand Central Palace, New York, in charge of Charles F. Roth.

Durable-Goods Industries Committee

AT ITS meeting on September 19, as noted elsewhere, the Executive Committee of the A.S.M.E. Council discussed the need for coöperating with the Durable-Goods Industries Committee. This committee was formed to represent the durable-goods industries. Its members were elected by the Code Authorities at the close of the Conference of Code Authorities in Washington, March 8, 1934. Under the chairmanship of George H. Houston, of the Baldwin Locomotive Works, Philadelphia, Pa., the committee set up headquarters in Washington and undertook a study of the problems arising out of the NRA and the recovery program that confront the durable-goods industries. Among other activities the committee prepared a "Report to the President of the United States on National Recovery and Employment" which received very favorable comment in the press.

At a recent meeting, the committee was reorganized and the members nominated by the organization committee were unanimously elected. Mr. Houston, who retains the chairmanship, the vice-chairman, James W. Hook, Geometric Tool Company, New Haven, Conn., and S. F. Voorhees, Voorhees, Gmelin, and Walker, New York, N. Y., member of the committee, are members of the A.S.M.E.

Journal of Applied Mechanics

AS A RESULT of action taken on Sept. 19, 1934, by the Executive Committee of the A.S.M.E. Council, a Journal of Applied Mechanics is to be published under the auspices of the Applied Mechanics Division and the Committee on Publications. The object of the journal is to provide an adequate outlet and place of record of research in the field of applied mechanics. As it is to be developed, it will contain papers presented before the Applied Mechanics Division at A.S.M.E. meetings, other papers of like character, reviews of books and foreign articles of importance, notes of interest, and like material. The normal A.S.M.E. financial support for the publication of the papers presented by the Applied Mechanics Division is expected to be amplified in part by outside contributions. The Journal of Applied Mechanics is to be distributed to members of the Society desiring it without charge and to subscribers. The format of the Journal will be identical with the A.S.M.E. Transactions. The policies of the Journal will be in charge of an editorial board appointed by the Applied Mechanics Division Executive Committee subject to the approval of the Committee on Publications and the Council.

A.S.M.E. Transactions for October, 1934

THE October, 1934, issue of the Transactions of the A.S.M.E. contains the following papers:

A Mathematical Solution of the Rotor-Balancing Problem (APM-56-14), by Jacob Bromberg

Effect of Skewing and Pole Spacing on Magnetic Noise in Electrical Machinery (APM-56-15), by S. J. Mikina

Effects of Side Leakage in 120-Degree Centrally Supported Journal Bearings (APM-56-16), by Sidney J. Needs

Exact Construction of the $(\sigma_1 + \sigma_2)$-Network From Photoelastic Observations (APM-56-17), by Heinz P. Neuber

New Method of Calculating Longitudinal Shear in Checked Wooden Beams (APM-56-18), by J. A. Newlin, G. E. Heck, and H. W. March

Dynamic Balancing of Rotating Machinery in the Field (APM-56-19), by E. L. Thearle

High-Pressure-Steam and Binary Cycles as a Means of Improving Power-Station Efficiency (FSP-56-11), by Gustaf A. Gaffert

Influence of Bends or Obstructions at the Fan-Discharge Outlet on the Performance of Centrifugal Fans (FSP-56-12), by L. S. Marks, J. H. Raub, and H. R. Pratt

The Relative Grindability of Coal (FSP-56-13), by H. J. Sloman and A. C. Barnhart

Pulsating Air Flow (PTC-56-1), by Neil P. Bailey

The V-Notch Weir for Hot Water (RP-56-9), by Ed S. Smith, Jr.

Calibration of Rounded-Approach Orifices (RP-56-10), by J. F. Downie Smith.

Mechanical Catalog Issued

THE twenty-fourth annual Mechanical Catalog was published on October 1 by The American Society of Mechanical Engineers. The catalog has three sections: The "Index to Catalogs," refers to the page on which the products of the company are described and contains a brief historical statement about the company and its product. The "Catalogs of Advertisers," arranged alphabetically by names of companies, contains illustrated descriptions of the products manufactured by the companies represented in the book. The "Index to Manufacturers" contains the names and addresses of 665 firms, and lists, under 4000 classifications, thousands of items used by industry. It is also an index to the descriptions of the specific products provided by the advertisers in the catalogs that comprise this section of the book.

Election of A.S.M.E. Officers for 1935

THE result of the election of officers of The American Society of Mechanical Engineers for 1935 is as follows:

Office	Nominee	Votes
President	Ralph E. Flanders	3006
Vice-Presidents	James H. Herron	3013
	Eugene W. O'Brien	3006
	Harry R. Westcott	3007
Managers	Bennett M. Brigman	3007
	Jiles W. Haney	3011
	Alfred Iddles	3009

Biographical sketches of the nominees for office may be found on pages 503–506 of the August issue of Mechanical Engineering.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after November 26, 1934, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

New Applications

Blossfield, Eugene F., Brooklyn, N. Y.
Burgess, Donald, Buffalo, N. Y.
Clarke, Capt. C. W., Parel, Bombay, India
Craft, Harry W., Jr., St. Louis, Mo.
Crafts, Curtis S., Chicago, Ill.
Dun, Henry W., Jr., Wilton, Conn.
Friedman, Gerald, Richmond Hill, L. I., N. Y.
Haydock, John, New York, N. Y. (Rt & T)
Helfter, Franklin S., Buffalo, N. Y.
Kuriloff, Arthur Harold, Brooklyn, N. Y.
Lewis, Irving R., Jr., Bloomfield, N. J.
Lewis, Richard C., Mountain View, Calif.
Marchant, William H., Alhambra, Calif.
Morgan, George R., Greenville, S. C.
Morlan, Erwin A., Gunnison, Colo.
Nicoletti, George W., Chicago, Ill.
Pashkoff, Nat George, New York, N. Y.
Pitts, Howard H., Chicago, Ill.
Reggiori, Alessandro, Milan, Italy
Roeseler, Ernest F., Red Lodge, Montana
Roulston, Robert K., New York, N. Y.
Stappert, Otto E., Queens Village, L. I., N. Y.
Stockwell, Ray C., Buffalo, N. Y.
Sutton, Wilson L., Bristol, Pa.
Thornton, Lieut. W. N., Bedford, Mass.
Tranzen, Karl, Chicago, Ill.
Wahl, Richard, Denver, Colo.
Walker, Gerald C., New York, N. Y.
Walton, Sylvan Brooks, Santa Monica, Calif.
Washburn, Franklin E., Watertown, Mass. (Rt & T)
Wiberg, Richard E., Ansonia, Conn.
Young, Almon Paul, Houghton, Mich.

Change of Grading

Transfers from Associate-Member

Gopalakrishna, Seshier, Bangalore, India
Rietz, Carl A., San Francisco, Calif.
Smith, Elwyn L., Syracuse, N. Y.

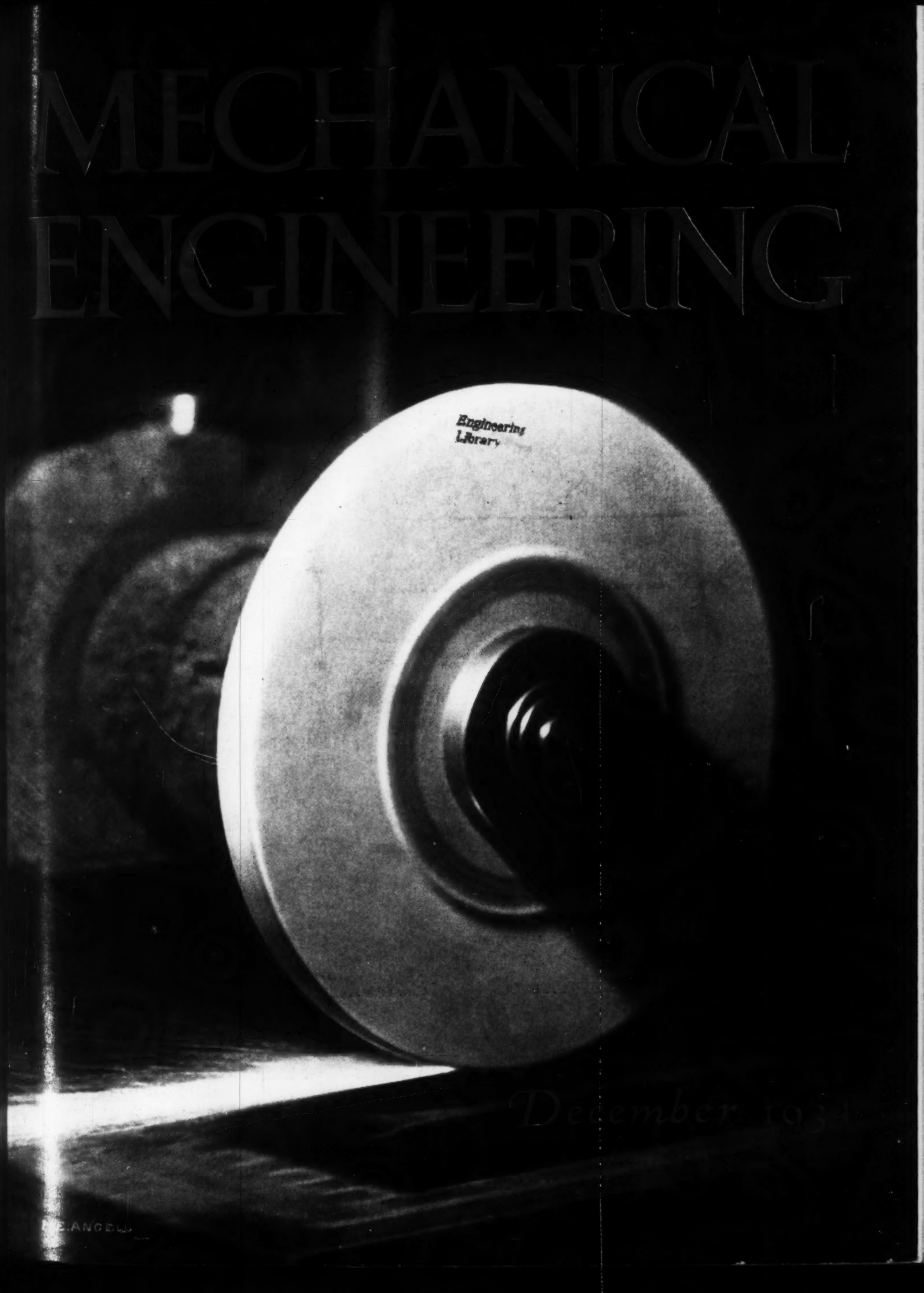
Transfers from Junior

Alexander, D. H., Belfast, Ireland
Amidon, Lee L., Morgantown, W. Va.
Benson, Arthur E., Chicopee Falls, Mass.
Brainard, Prof. Boyd Bertrand, Manhattan, Kans.
Carter, R. Jefferson, London, England
Church, Austin H., New York, N. Y.
Colby, Allan B., Lancaster, Pa.
Corey, D. H., Detroit, Mich.
Davis, F. R., San Diego, Calif.
Dornbirer, Wayne M., Columbus, Ohio
Eksergian, C. Levon, Detroit, Mich.
Espig, Erwin E., Buffalo, N. Y.
Evans, J. N., Brooklyn, N. Y.
Galson, Henry L., Swarthmore, Pa.
Gregg, Frank D., St. Louis, Mo.
Gudmundsen, Austin, Milwaukee, Wis.
Habicht, Ernst R., Charleston, W. Va.
Hausman, Moses, New York, N. Y.
Juchtern, Charles D., Brooklyn, N. Y.
Mahon, William J., Mexico D. F., Mex.
Martyn, W. S., Buffalo, N. Y.
McChesney, Irvin G., East Rochester, N. Y.
Muller, Daniel L., New York, N. Y.
Oppenheimer, E. A., Cedar Rapids, Iowa
Petersen, Alfred V., Union, N. J.
Phelps, Charles W., Storrs, Conn.
Reyna, Leon C., Brooklyn, N. Y.
Roesel, Arno Fritz, Elizabethton, Tenn.
Rumble, Virgil A., San Francisco, Calif.
Spicacci, A. R., Bristol, Conn.
Spitzglass, A. F., Chicago, Ill.
Stevens, George W., Detroit, Mich.

Recent Deaths

Fray, William, July 22, 1934
Huestis, Bronson L., May 29, 1934
Morrin, Thomas, August 1, 1934
McClellan, George F., September 17, 1934
Neefus, Harold Van H., August 23, 1934
Page, George B., September 10, 1934
Rice, Calvin W., October 2, 1934
Seymour, Joseph W., July 2, 1934
Smith, Geo. Hotchkiss, June 7, 1934
Struckmann, Edwin, March 15, 1934

MECHANICAL ENGINEERING



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